INTERNATIONAL ENERGY AGENCY
LATIN AMERICAN ENERGY ORGANISATION

INTERNATIONAL COOPERATION FOR RATIONAL USE OF ENERGY IN INDUSTRY

Proceedings of an International Seminar on Rational Use of Energy in Industry organized by the Latin American Energy Organization, the International Energy Agency, the Ministry of Energy and Mines of the Republic of Peru, and the Commission of the European Communities.

LIMA
4-8 July 1983

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FOREWORD

National and international energy policies have increasingly recognized over the last decade the necessity of a more rational use of energy, in particular of scarce depletable and costly energy resources such as oil. Improving energy efficiency means enhancing general economic productivity and competitiveness and reducing national dependence on energy imports. It helps to develop domestic resources and employment and to ease pressures on the national balance of payments. Overall, it will have to play a major role in developing better balanced, more economic and stable energy economies in all countries of the world.

Industry is the greatest energy consuming sector in many regions of the world. It also provides large potentials for further progress in energy efficiency. It was, therefore, decided to hold a seminar on rational use of energy in industry which took place in Lima from 4th to 8th July, 1983, and was jointly organised by the Latin American Energy Organisation (OLADE), the International Energy Agency (IEA), the Commission of the European Communities (EEC) and the Government of Peru. Financial support for the Seminar was also received from the Government of the Federal Republic of Germany, the Canadian International Development Agency (CIDA) and the United States Agency for International Development (USAID). The Seminar was formally inaugurated and closed by Dr. Fernando Montero Aramburu, Minister of Energy and Mines, on behalf of the President of the Republic of Peru, Fernando Belaunde Terry.

In addition to representatives of the organizing institutions and other international organisations, representatives of the public and private sectors from the following member countries of OLADE, IEA and EEC also took part: Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Uruguay, Venezuela, Federal Republic of Germany, Australia, Canada, Denmark, Spain, United States of America, France, Netherlands, United Kingdom, Italy and Japan.

The aim of the Seminar was to exchange experiences between OLADE, IEA and EEC countries in the field of rational use of energy in a number of industrial sectors such as textiles; generation, transmission and distribution of electricity; iron and steel; non-ferrous metals; cement; and sugar. Instruments and technologies for rational use of energy in industry were also discussed as well as possibilities for international cooperation in this field.

The 29 presentations on these issues by 14 experts from IEA/EEC countries and 15 from Latin America and the World Bank represented a wide spectrum of background and experience in the field of rational use of energy in industry. All were invited to participate in the Seminar in their individual capacities as experts in their fields. Thus the technical papers and summaries of discussions in this publication represent their views alone and should not necessarily be taken to represent the views of their governments or organisations.

The Seminar provided the platform for a most useful exchange of views based on the presentations which were of high technical quality. Its success has underscored the utility of international cooperation of this type in bringing together people of differing backgrounds and experience but with the common objective of making more rational use of a precious resource.

Our thanks are due to all who contributed to this success; the speakers, those who gave financial support, the Government of Peru for its most generous hospitality and to all those who helped assure the successful outcome.

By publishing the proceedings of the Lima Seminar, OLADE and IEA intend to make the important information that was under discussion at this meeting available to all interested parties, both in developing and developed countries. At the same time we want to convey the message that there is not only a need but a real chance to cooperate on a broad international basis to bring about a better global energy balance in the present era of energy transition.

Ulises Ramirez Olmos
Executive Secretary
Latin American Energy Organisation

Ulf Lantzke
Executive Director
International Energy Agency

AGENDA

AND

COMPOSITION OF BUREAUX

Monday, 4th July, 1983

Welcome and introduction to the Seminar by:

- Ubaldo Zito,
  Head of Energy Savings Division,
  Commission of the European Communities (EEC)

- J. Wallace Hopkins
  Deputy Executive Director
  International Energy Agency (IEA)

- Ulises Ramírez Olmos
  Executive Secretary
  Latin American Energy Organisation (OLADE)

- Fernando Montero Aramburu
  Minister of Energy and Mines
  Republic of Peru

MANAGEMENT OF ENERGY DEMAND IN INDUSTRY*

Chairman: Ulises Ramírez Olmos
Executive Secretary of OLADE

Speakers:

- Dietrich Barth
  Head of Energy Conservation Division
  IEA

- Cornelio Marchan
  Director of Economic Studies and
  Energy Planning, OLADE

- Donald Tarnawiecki
  UNDP/MEM
  Peru

Rapporteur: Gloria Villa
Costa Rica

* All speeches on a given sector were followed by a question-and-answer session.

RATIONAL USE OF ENERGY IN THE TEXTILE INDUSTRY

Chairman: J. Wallace Hopkins
Deputy Executive Director
IEA

Speakers:

- M. W. Horning,
  General Energy Policy Department
  Ministry of Economic Affairs
  Netherlands

- Hugo Serrano Marino
  Superintendent of Technical Services
  ENKA de Colombia

Rapporteur: Carlota Huaroto
Peru

Tuesday, 5th July 1983

RATIONAL USE OF ENERGY IN THE GENERATION, TRANSMISSION AND DISTRIBUTION OF ELECTRICITY

Chairman: Augusto Martinelli Tizón
President Electrolima

Speakers:

- Teofilo de la Torre
  Costa Rican Institute of Electricity
  Costa Rica
  (Presented by Mario Hidalgo Pacheco
  Costa Rican Institute of Electricity)

- Siegfried Schindler
  Engineering and Sales Manager
  Kraftwerk Union AG
  Federal Republic of Germany

- Francisco Granadino
  Lempa River Executive Hydroelectric Commission
  El Salvador

- Knut Berge
  Head of Engineering Development Department
  ELKRAFT Power Co.
  Denmark

Rapporteur: Roland Castillo
Guatemala

RATIONAL USE OF ENERGY IN THE IRON AND STEEL INDUSTRY

Chairman:

Rene Barbis
Regional Secretary
ILAFA
Peru

Speakers:

- Julian Jatem
  Head of the SIDOR Research Center
  Venezuela

- Naoaki Suzuki
  General Manager
  Nippon Steel Corporation
  Japan

- Rosenval Jorge de Oliveira
  President of the Energy Committee
  Brazil

- Marc Grumbach
  Institute of Iron and Steel Research
  France

- Eli Campos Sandoval
  Altos Hornos de Mexico, S.A.
  Mexico

Rapporteur:

Gloria Figueroa
Venezuela

<u>Wednesday, 6th July 1983</u>

RATIONAL USE OF ENERGY IN THE NON-FERROUS METALS INDUSTRY

Chairman:

Erik Tjon Kie Sim
Minister of Natural Resources and Energy
Suriname

Speakers:

- Hugo Bonomelli
  Technical Director of Codelco
  Chile

- Jane Carter
  International Energy Efficiency Consultants
  England

- Ralph L. Sheneman
  Branch Chief
  Department of Energy
  United States

- César Fuentes
  Manager of the Zinc Refinery of Cajamarquilla
  Peru

Rapporteur: Graham T. Armstrong
Canada

Thursday, 7th July 1983

RATIONAL USE OF ENERGY IN THE CEMENT INDUSTRY

Chairman: Dietrich Barth
Head of Energy Conservation Division
IEA

Speakers:

- Vladimiro Camacho Rodriguez
  Samper Cement Company
  Colombia

- Brian Wilson
  Former Research Manager of
  Goliath Portland Cement Co.
  Australia

Rapporteur: Jane Carter
England

RATIONAL USE OF ENERGY IN THE SUGAR INDUSTRY

Chairman: Altagracia Rivera de Castillo
GEPLACEA

Speakers:

- Luis O. Gálvez Taupier
  Vice-Minister of Sugar
  Cuba
  (Presented by Roberto Cáceres, OLADE)

- Juan Carlos Llorente Chala
  Programme Director
  Ministry of Industry and Energy
  Spain

- Arnaldo Veras
  IICA

- Segundo Torres
  Uruguay

- Marco Campodinica
  GEPLACEA

- José Villanueva
  Peru

Rapporteur: Roberto Cáceres
OLADE

INSTRUMENTS AND TECHNOLOGIES FOR RATIONAL USE OF ENERGY IN INDUSTRY

Chairman: Raúl Fajardo
General Director
ITINTEC
Peru

Speakers:

- Gary Gaskin
  Energy Department
  World Bank
  and
  Julio R. Gamba
  Industry Department
  World Bank

- Fausto Furnari
  IPT
  Brazil

- Graham T. Armstrong
  Director of Policy and Co-ordination
  Department of Energy, Mines and Resources
  Canada

- Ubaldo Zito
  Head of Energy Savings Division
  EEC

- José Ramón Acosta
  Dominican Republic
  (Presented by Francisco Castillo
  Dominican Republic)

Rapporteur: Jorge Aguinaga
Peru

Friday, 8th July 1983

POSSIBILITIES FOR INTERNATIONAL CO-OPERATION
IN THE FIELD OF RATIONAL USE OF ENERGY

Chairman: Basil B. Buck
Minister of State
Jamaica

Speakers:

- Ulises Ramírez Olmos
  Executive Secretary
  OLADE

- J. Wallace Hopkins
  Deputy Executive Director
  IEA

- Ignacio Soto
  Ministry of Energy and Mines
  Peru

Rapporteur: Eduardo Pascual
OLADE

ADOPTION OF THE FINAL REPORT

CLOSING SESSION

Closing remarks by:

- Ulises Ramírez Olmos
  Executive Secretary
  OLADE

- J. Wallace Hopkins
  Deputy Executive Director
  IEA

- Fernando Montero Aramburu
  Minister of Energy and Mines
  Republic of Peru

FINAL REPORT OF THE INTERNATIONAL SEMINAR ON RATIONAL USE OF ENERGY IN INDUSTRY

I. INTRODUCTION

1. The Seminar on Rational Use of Energy in Industry was held in the city of Lima, from 4th to 8th July, 1983. It was organized by the Ministry of Energy and Mines of Peru, the Latin American Energy Organization (OLADE), the International Energy Agency (IEA), and the Commission of the European Communities (EEC). It was carried out under the auspices of the United States Agency for International Development (USAID), the Government of the Federal Republic of Germany and the Canadian International Development Agency (CIDA).

2. The event was opened and closed by the Minister of Energy and Mines of Peru, Dr. Fernando Montero Aramburu, on behalf of H.E. The Constitutional President of the Republic of Peru, Fernando Belaunde Terry, and the Government of Peru. The Minister of State of Jamaica, Basil B. Buck; the Minister of Natural Resources and Energy of Suriname, Erik Tjon Kie Sim; the Executive Secretary of OLADE, Ulises Ramirez; the Deputy Executive Director of the International Energy Agency, J. Wallace Hopkins; and Mr. Ubaldo Zito, representative of the Commission of the European Communities, also participated in the Seminar.

3. 193 representatives of the public and private sectors from the following member countries of OLADE, IEA and EEC participated in the Seminar: Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Uruguay, Venezuela, Federal Republic of Germany, Australia, Canada, Denmark, Spain, United States of America, France, Netherlands, United Kingdom, Italy and Japan. Aside from the organizers, representatives from the following international institutions also participated: IDB, UNDP, World Bank, GEPLACEA, ILAFA, IICA, ICAITI, ECLA, UNIDO, SIECA, JUNAC and OAS.

4. The Seminar was developed within the framework of the Latin American Energy Cooperation Program (PLACE) and the cooperation programs of the International Energy Agency and the European Communities. It also forms part of the activities of the organizing institutions towards fostering the rationalization of energy production and consumption in their member countries.

5. The major objective of the event was to promote the exchange of experiences in the field of rational use of energy in the industrial sector among the Latin American countries and between these and the industrialized countries, as well as to identify possibilities for international cooperation in this field.

6. The industrial sectors analyzed during the event were: textiles; generation, transmission and distribution of electricity; iron and steel; non-ferrous metals; cement; and sugar. Several aspects of industrial energy management instruments and technologies as well as possibilities for international cooperation in the field of rational use of energy in industry were also dealt with. In all, 29 central papers were presented: 14 by speakers from industrialized countries and 15 from Latin America.

   Fifteen official and individual contributions from OLADE member countries were also distributed.

   Nine working sessions were set up to analyse the topics dealt with in the papers and to elaborate a set of conclusions and recommendations.

   During the event a visit was made to the Zinc Refinery of Cajamarquilla, located 29 kms. northwest of Lima.

11.a.

OPENING REMARKS
BY
UBALDO ZITO
COMMISSION OF THE EUROPEAN COMMUNITIES

Mr. President, Ladies and Gentlemen

1) It is an honour for me today to participate, together with Dr. Ramirez, Mr. Hopkins and his Excellency Mr. Montero, Minister of Energy and Mines of Peru, in the opening session of this important international seminar on rational use of energy in industry.

On behalf of the Commission of the European Communities, I would like to warmly thank the Peruvian Government for hosting this seminar. This demonstrates once more the deep involvement of Peru in the development of international cooperation.

Since ariving only last night, I have been tasting the pleasure of spending a week in this historic and beautiful Latin American country.

On this occasion, I would also like to thank Dr. Ramirez, Executive Secretary of OLADE and Mr. Hopkins, Deputy Executive Director of the International Energy Agency, together with their staff, for all the effort put into the organizing of this seminar, jointly with the Commission of the European Communities.

2) Rational use of energy is a subject of a great importance. Today, productivity in the use of energy is a central theme of economic, industrial and employment policies.

The transition to greater energy efficiency and the substitution of oil by other fuels, remains a primary goal of all our Governments.

The challenge must be to use a drive for energy-efficiency as a means of becoming more prosperous, not less prosperous.

The central idea of rational use of energy is that energy resources can be used more efficiently by applying measures which are technically feasible, economically justified and acceptable from the environmental and social point of view.

To achieve this, we still need better management to gain higher energy efficiency in all phases of using natural resources, from exploitation to utilization.

3) The past three years have brought dramatic changes on the world oil market as it adjusts to new and very different market conditions. The price increases of 1979/80 contributed substantially to the damaging depression of economic activity which has been witnessed throughout the industrialized world. But on the positive side, they had a direct effect on the demand for oil and on the supply and use of other fuels. They also changed the perceptions and behaviour of Governments in oil-consuming and oil-producing countries alike, and those of companies and individuals inside and outside the oil industry.

The combination of these factors pushed world oil demand down by a staggering 20% in 3 years and with this has come the fall in the price of crude oil itself.

These changes carry important lessons for energy policy and set a new context for future action. The new situation requires a different response from that of the past, building on the successes of the past but learning from the mistakes; capitalizing on the opportunities while minimizing the risks; and providing a solid bridge from the present to a more certain future.

4) <u>The Lessons of the Past</u>

One key lesson from the past is that energy policy brings clear rewards. Some of the gains that have been made are due to the efforts of Governments to encourage more rational energy use and a less vulnerable and more diversified pattern of energy supply.

Another lesson is that market forces are very much alive and well in the energy field, working during the past three years vigorously in support of our energy policy objectives.

5) We must not assume that the present oil market situation is here to stay. If, as a result of this new situation, the short-term economic outlook will be better for all countries, the longer-term is clearly less secure.

We have meanwhile a "breathing space", to consolidate the gains of the past and to put the future on a sounder footing.

6) Falling oil prices and changing perceptions about their future evolution will certainly make the realization of the rational use of energy objectives even more difficult.

The risks are of two kinds: The first is that Governments will put energy policy on a back-burner as the other and more immediately pressing issues of employment and inflation continue to dominate the political debate.

The second is that consumers and investors in both the public and private sectors will see little market incentive to sustain the pace of restructuring when investments outside the energy sector begin to show substantially quicker returns as the relative price of energy falls.

7) But rational use of energy is so fundamental to the successful pursuit of the general economic aims that it should have special priority treatment. If the main objective of energy policy is to prevent a rationing in the growth of goods and services in the years to come, rational use of energy investment should be made a major beneficiary rather than a potential casualty of falling oil prices.

By using in the energy sector some of the resources freed by falling oil prices, the risk of a longer-term energy constraint on growth can be reduced.

8) <u>This is the background to our Seminar</u>

I am sure that our discussions and conclusions here this week will be a major contribution to those people involved in Government and industry who have to cope with these problems.

II.b.

OPENING REMARKS
BY
J. WALLACE HOPKINS
DEPUTY EXECUTIVE DIRECTOR
IEA

Mr. President, Ministers, Ladies and Gentlemen,

The International Energy Agency is pleased to be represented here in Lima to take part in this co-operative effort with OLADE, the Commission of the European Communities and the Government of Peru. We are especially grateful to the Goverment of Peru for providing such excellent facilities in this ancient, famous and delightful capital city. We are grateful also to the European Commission and to the Goverments of the United States, Germany and Canada for their financial contributions. And, we thank the World Bank and the Inter-American Development Bank for their active participation in this event, and of course also all the individual speakers, many of whom have travelled long distances to share their experience with this seminar. I would like also to express my personal appreciation to Dr. Ulises Ramirez and his splendid staff at OLADE headquarters. I know that he and they have worked long and hard to bring this event about, and his inspiration and persistence have been an indispensable support to everyone working on this project.

All these contributions are clear evidence I think, to two main points:

- first, - the importance which countries, organisations and individuals attach, in their own work, to energy, and especially to the rational use of energy;

- and the second - the importance of co-operative international activities, among countries, and within organisations and between organisations, in overcoming energy problems. This clearly reflects the fact that energy is fundamentally an international matter.

Energy is the largest single category of international commerce. Energy trade flows account for more than 25 per cent of all world trade.

No nation can be considered truly independent in energy terms. A few countries may be self-sufficient in one or more fuels, but for the long-term, every country will have to play an international role in energy.

Within the overall energy field, "energy conservation" is the term we have traditionally used as a shorthand expression. But it is not really a very good term. We are moving more to the term "rational use of energy" because it expresses two ideas - energy efficiency, and the appropriate choice of fuel mix. Thus it conveys a sense of the true value of energy to our society - not the sense of saving energy by "doing less", but rather "doing more with less energy" for many cases, even using more energy but getting far more economic and social benefits than if it is used unwisely. It also reflects the importance of a balanced fuel mix which is more efficient and stable than heavy concentration in any one fuel.

The benefits of energy efficiency are numerous and widely recognised:

- it generally increases output and productivity for a given input of costly energy.

- it helps to improve the balance of payments, both for energy importers by reducing potential import bills, and also for energy exporters by increasing the total amount of their resources available for export over the longer term;

- it improves the ability of economies to adjust to sudden changes in energy markets;

- it provides time for the transition toward the period when depletable fossil fuels will no longer be able to provide the bulk of energy needs.

These are all important subjects in the short-term, and especially under the economic conditions which are prevalent in the world today.

But they also have a strong long-term component. Changes in energy-use patterns take a long time; they depend on the habits and decisions of millions of individual consumers; and many decisions on energy efficiency become fixed for years in a capital stock of boilers, cars, roads, houses, factories. What we decide now will therefore affect our energy economies for a very long time to come. And of course, it is this long-term component which is the more difficult to get across politically.

So much for energy itself. Now I should like to mention the second main reason which brings us all together, and that is the recognised need, and the demonstrated willingness, for international co-operation. This gathering expresses two different, but complementary, elements.

First, the common agreement which exists within organisations, and to a very large extent among them, as to the importance of moving together to achieve similar goals, which can broadly be expressed as a stronger world economy. This would bring us together, whether we are net exporters or net importers, whether we are industrialised or developing countries, whether our economies and industries are managed more by the State or by the private sector, and whether our political institutions differ.

Secondly, the fact that these differences do exist. They are indeed a source of richness and strength, but they also mean that though policy goals are similar, the specific policies used to reach them must be tailored to the specific situation of each country, its traditions, its institutions, its economic and political structures.

Finally, we have learned that the subject of energy, and especially the rational use of energy, is far more complex than it may appear at first glance. The use of energy is thoroughly tied up to almost every goal which our societies seek, from economic growth to all the individual social goals which grow from that. It is easy to proclaim one's support for a goal as universally accepted as the rational use of energy, but it is another thing to make the difficult political decisions about funding and pricing which are often involved.

For energy questions are profoundly political - both because of their importance to the lives and well-being of our nations and our peoples, and because of the difficulties all governments face in building the public understanding and support necessary to achieve effective results.

You will hear more about this in detail from experts from many countries during the course of this week. Each of our countries, each of our organisations, have had different experiences in this field - some successful, some less successful. But the problems that face all of us in improving energy efficiency, and finding a better fuel mix, particularly in industry, are similar enough that we should all be able to learn from one another. This is, of course, the very essence of international co-operation - drawing on common agreement as a foundation and using the diversity of individual experiences and circumstances to arrive at a better result than any of us could achieve alone.

This is the basic raison d'être of the International Energy Agency and all other energy organisations - to share one's own experience and to learn from the experiences of others. We are happy to be here for that purpose this week on a broader international scale, and as our work together progresses, I will be happy to discuss ways in which this kind of co-operation could be carried forward and expanded.

Thank you.

II.c.

OPENING REMARKS
BY
ULISES RAMIREZ
EXECUTIVE SECRETARY
OLADE

"What is destroyed is of no use to anyone; in a word, what is destroyed is ours and little remains for us to destroy".

This quotation from the liberator Simon Bolivar, recalled here today only shortly after the celebration of the bicentennial of his birth, gains special significance, because it indicates how the forgers of our young nations gave special attention to arousing awareness as to the value of preserving moral and material resources.

Conservation has thus aided in shaping our energy culture. While nowadays this includes an important external component, based on our emulation of the consumption patterns of industrialized nations, for Latin America the concept of energy savings refers more to the transfer of each calorie saved from wasteful ends to the satisfaction of the needs of those sectors of the population that have been deprived. Thus it is not a question of saving "for the sake of saving", but rather saving in order to increase supply; hence the Seminar at which we are present today and at which the keynote topic is rational energy use. This clearly, demonstrates the degree of awareness of our society, of the need to utilize our ability to reason in order to avoid the waste of the scarce, non-renewable energy that has been fueling the world economy.

This rationalizing process has applications ranging from more widespread development of our indigenous resources, to actions taken in the process of transformation and end use in order to avoid waste.

In this regard, we are facing, from the technological standpoint, the same realities as those faced by the developed world; but, nevertheless we have available a wider range of alternatives: on the one hand, there is an abundant diversity of energy resources, within which hydrocarbons hold an important place, alongside hydroenergy, coal and geothermal energy, biomass and solar radiation. At the same time, while the structure of our consumption is based on the intensive use of hydrocarbons, the intensive use of biomass, with its adverse effects on the ecology and the agricultural economy, is not to be overlooked.

The ideas set forth above indicate that we have to use our indigenous resources in a more appropriate fashion, exploiting those of lower social costs and great availability, guaranteeing environmental protection and permitting the substitution of ill-used petroleum. Likewise, we have the responsibility of transforming our inefficient industrial plant and services into one that consumes a smaller amount of energy per unit of product.

Both alternatives must cope with the reality of a world in which they must compete for financial resources at a moment of international crisis, especially for the Latin American countries.

Fortunately, in Latin America, energy is not and has never been a motive for confrontations between oil importers and exporters; instead, it has opened the way for more intensive institutional and commercial relations, as demonstrated by the Cooperation Agreement of Mexico and Venezuela and the Trinidad and Tobago Oil Facility, with Central American and Caribbean countries, as well as the existence, within OLADE, of the Latin American Energy Cooperation Programme (PLACE), by means by which all of our installed capacity in the energy sector is mobilized to foster evaluation, development and better utilization of the Latin American potential. These programs thus serve as an example of how Latin America is meeting this transitional stage of energy development, in an orderly and coherent way, and with a great sense of solidarity.

Along with this movement of South-South cooperation, we want to have collaboration from the North, because we are aware of the fact that in the inter-dependent world of today no country is an island able to resolve its most pressing needs by itself. It is therefore necessary to seek out alternatives to make this cooperation flow within the framework of international social justice, which it will only be possible to obtain through a frank dialogue such as the one we are about to embark upon in the interesting field of energy use in industry. Indeed, in this regard, it is worthwhile to note the diversity of support that has come together for the realization of this Seminar.

First and foremost we must recognize the support of the Peruvian nation, whose government has opened its doors to us through the Ministry of Energy and Mines, as personified by Minister Fernando Montero. Just as in 1973, when here in Lima the founding document of OLADE was signed, and in 1981 when the formulation of the PLACE was consolidated, results will be produced within the framework of the postulates of the North-South Dialogue to strengthen the establishment of a New International Economic Order.

Secondly, the International Energy Agency and the Commission of the European Communities, have recognized with foresight the importance of the place which regional organizations such as OLADE may well hold by the end of the century. To these two organizations, as well as the Governments of Germany, Canada and the United States, which contributed to funding this Seminar, we must acknowledge their happy initiative.

Mr. Minister of Peru, I would request you to extend to the President of the Republic, on behalf of the energy community gathered together on this occasion, our most heartfelt expressions of gratitude for your country's generous hospitality, and our desire that the work undertaken here this week may produce special benefits for your country as one member of the family of Latin American nations.

Mr. Delegates, the state is set for you, who represent the most important activity on the energy consumption scene, that is industry, to orient us and guide us in an appropriate direction in this year of OLADE's tenth anniversary and its new phase which we term "Energy Self-Sufficiency with Technological Autonomy".

May our accomplishments serve to strengthen the confidence of our peoples in their governments, in their businessmen, and in international cooperation.

Thank you very much.

OPENING REMARKS
BY
H.E. FERNANDO MONTERO ARAMBURU
MINISTER OF ENERGY AND MINES OF PERU

On behalf of President Fernando Belaunde and the Government of Peru, I am pleased to extend to you all a most cordial welcome and, at the same time, congratulate the Latin American Energy Organization for the initiative of organizing this Seminar, which we feel to be transcendent. In doing so I would also like to thank the International Energy Agency and the Commission of the European Communities, as well as those friends who have supported this Seminar; because I believe that the support of all these persons and institutions has made it possible to bring together here in Lima a high-level technical group from developed and developing countries alike, which will surely permit an exchange of mutually beneficial experiences.

This Seminar is being held at a particularly critical moment in time. In Latin America, the international recession, which began to sharpen as of 1980 and which has given rise to a substantial drop in the prices of the Latin American countries' major exports, both of raw materials as well as manufactured goods, has brought about serious deterioration in our terms of overseas trade. Later on, as a result of the monetary policies applied by the developing nations, the world as a whole experienced higher interest rates, which complicated still further a panorama which had already become critical. Currently, we are facing a series of problematic restrictions in the fields of credit and trade.

This set of circumstances shapes a critical panorama, and it is possible that some of you are wondering what all this is leading up to. This is a seminar on energy and not on international economic policy. However, I think it fundamental to mention this concern of the Latin American countries, regarding a problem which is certainly one of the utmost urgency in today's world for we are of the opinion that this problem is not going to be resolved if there is no dialogue and no concerted effort based on the belief that we are living, as Prime Minister Trudeau has said, in a world of growing interdependence in which the policies that are being adopted must take into consideration that the world is one and that there is no room for egoistic policies which will inevitably turn but to be, as they always have, counterproductive.

You must pardon this digression, yet it is important to touch on this urgent theme before going on to the keynote of the meeting, and I think it is timely to indicate those aspects which are foremost in our minds; neither would I like to fail to mention the importance of Rational Use of Energy today, and I am sure that we here present feel that this will continue to be an enormously opportune and transcendent topic in the future.

Usually, in handling goverrment affairs there has to be a balance and a set of priorities which are sometimes difficult to get, in terms of what is urgent and what is important. This week I think we are going to be dedicated to dealing with affairs of singular importance.

I am convinced that this problem and this subject dealt with here today are indeed of singular importance for consumers as well as for the economy as a whole. Furthermore, it seems to me that, through this topic, we are going to be able to deal with energy and energy problems in general, which hold so much interest for us. Again, planning and rational use of energy resources will continue to be highly topical in the future.

In Peru we have long years of experience in developing our energy resources, and we have a number of accomplishments in which we take great pride. Nevertheless, a realistic analysis of the situation in which we find ourselves today necessarily obliges us to be sober-minded. We are a country that still depends considerably on oil, a country in which we are using forestry resources to a greater extent than on oil, a country in which we are using forestry resources to a greater extent than our ability to replace them, a country in which the development of our abundant coal reserves is limited to a vanguard of small mining and industrial firms; and finally, we are a country which is taking its first steps toward the use of other sources of energy, leading to a diversified supply, the common objective of any country. However, we are working actively in this field, and Peru is granting great importance to the problem of energy planning and rationalization.

We are continuing with aid and cooperation with institutions such as OLADE, which are represented at this table, as well as many friendly countries. Base studies are underway to permit better planning of the country's energy structures and we are also moving toward an energy Conservation Center, in coordination with the Institute of Technological Research and Technical

Standards (ITINTEC); this institute, also resulting from international cooperation, has the fundamental aim of taking rational energy use and savings to public and private users, in the field of practical applications.

This Government, since 1980, has been taking measures to encourage oil exploration. The results have certainly been positive in terms of the sums earmarked for oil exploration and development, but not so in terms of the findings of recent years. Nevertheless, there have been other, encouraging aspects such as the development of some technologies which perhaps in the future will allow a greater utilization of the heavy oil that we have in our northern jungle; and perhaps this same kind of technological advance can have a great impact in some OLADE member countries having oil with similar features. In the field of electric power, investments have been substantially increased to give a push to hydroelectric resources, whose potential we have not fully tapped in Peru. The crisis to which I have referred has certainly limited the possibilities for executing projects in the most technically and economically feasible manner, deferring in many cases, and postponing in others, some of the main hydro power developments in the country.

We are also working actively to make more use of gas, coal and nuclear energy; and in this regard, we anticipate its use for exclusively peaceful ends, but we think that it can and should be one of the future sources within an economy having suitably diversified energy sources.

Finally, in terms of one of the most interesting aspects of this seminar, we have created a National Energy Council in which the public, private and academic sectors will be represented. The National Energy Council will work through a Technical Secretariat, which is the main organ of consultancy and advice from the Ministry of Energy and Mines; and through the Technical Secretariat which we already have working. It will have three main activities; first, to develop and achieve consistency among the different sources of energy, planning policies for the medium and long term; second, to implement rational use of energy, consisting both of savings as well as optimal utilization of each country's energy resource balance; and third, and very importantly, to develop new and renewable sources of energy.

We are truly at a critical moment, I have wished to refer to and briefly analyze some of the major problems that are affecting us; and I would like to thank all of you who are going to participate in this Seminar because I think that the nature of this event, the level of the papers, the institutions that have supported it and the speakers that will be participating - all of this will be an enriching and rewarding experience for all of us. In closing, may I, on behalf of the Peruvian Government, wish you success at the Seminar and reiterate that we are indeed honoured to have you here in this city of Lima.

Thank you very much.

FINAL CONCLUSIONS AND RECOMMENDATIONS

1. The continuous increases in oil prices that were witnessed in the last decade especially the sharp hikes of 1973 and 1979-80, have changed the economy of use for this form of energy and its derivates. After 1979, a change in perceptions took place, including the need to review previous energy policies and to consider programs for the conservation and rational use of energy.

2. The papers presented and the debates held here indicate that in the countries represented and in the sectors studied, there exists an important potential for energy savings in the industrial sector, and this should be explicitly considered within national energy plans. Nevertheless, there are constraints of an economic, technical and institutional nature which make it difficult to implement measures or which limit their results.

3. As a consequence, the appropriate development and use of this potential requires the State to define national policies in line with each country's concrete realities and coherent with its policies for the development of the sector as well as for the economy as a whole.

   To this end, it will be necessary to fully employ both the management capacity, incentives and disincentives, so that public or private enterprise makes adequate use of the potential for rational use of energy.

4. In this regard, the States should formulate and execute national programs including consciousness-raising and promotional activities which demonstrate the need for, and possibilities of, using energy as efficiently as possible.

5. Furthermore, within the limitations of the economic structures of each country, the instruments to be used must be accompanied by suitable pricing policies, while at the same time asuring that these are compatible with broader socio-economic objectives.

6. Likewise, it is necessary to develop and consolidate a technical infrastructure capable of providing the assistance and training required at the plant level. Where outside advice or other forms of international technical services are required, procedures aimed at guaranteeing a maximum transfer of technology to national firms and institutions should be employed.

7. Even within its financial limitations, the State should reorient internal resources in order for rationalization projects to find suitable amounts of funds under suitable conditions.

8. Continued programming for rational use of energy requires the development and consolidation of a suitable institutional base, by means of regulation and through the work of relevant organizations, all of which will permit the better coordination of public and private activity in this field.

The creation of national centers to encourage rational use of energy in industry should be a foremost element in institutional frameworks.

9. National programs for rational use of energy should consider regional cooperation as a necessary complement to improving the viability and effectiveness of national efforts in this area.

10. In order to attain this goal, it is useful for the Permanent Secretariat of OLADE to design and coordinate a program on the rational use of energy, which would take into account not only regional aspects of the problem but would serve as support for national action. Such a programme should study, inter alia, the following aspects:

a) Creation of awareness as to the importance of the rational use of energy.
b) Designs for surveys on energy consumption, energy balances by industrial sector, and studies on the conservation potential in specific industries.

c) Study of legal and institutional aspects related to the rational use of energy in the industrial sector.
d) Study of pricing policies and structures in Latin America.
e) Training of national staff for programmes of national cooperation in support of national efforts for rational use of energy in industry.
f) To promote and coordinate regional and international cooperation in order to support national efforts in the rational use of energy in industry.

11. The Member Countries and regional organizations should support the programme on rational use of energy proposed to OLADE, in order that existing experiences and resources might be joined in a cooperative effort geared to benefitting the energy development of Latin America.

12. Furthermore, the success of the seminar in Lima, reaffirms the importance of exchanging experiences between countries having different economic structures and levels of development. The participating organizations should continue such exchanges and should include in them new regions or groups of countries.

13. In this regard, it would be useful for OLADE to promote and organize, once every two years, an international seminar in which specialized speakers from all of the regions of the world would discuss the advances made in the field of rational use of energy.

14. Within this spirit of cooperation, the industrialized countries and the international organizations alike, should give OLADE technical and financial support necessary for the realization of the program and future seminars on rational use of energy proposed to that Organization.

15. It is recommended that the international development agencies allocate higher priority to projects for the rational use of energy and support national programs in this area.

16. It should be reiterated that OLADE is the suitable channel for making viable international cooperation programs for the rational use of energy in Latin America.

17. Finally, the organizing entities and participants recognize the efforts and the hospitality of the Government of Peru, as expressed through the Ministry of Energy and Mines and the national enterprises of the industrial sector, without whose firm and enthusiastic support this Seminar would not have been successful.

Energy Demand Management in Industrialised Countries

Introductory remarks by Dietrich Barth
Head of the Energy Conservation Division
International Energy Agency

I Introduction

Ever since the 1973 oil crisis, OECD countries have used various international fora to develop national energy policies through a co-operative approach. Members of the International Energy Agency adopted twelve Principles for Energy Policy in 1977 and agreed on further, more specific, guidelines at subsequent Ministerial meetings. Others co-operate in the framework of the European Communities. Energy problems have also been given repeated focus at the meetings of the Economic Summit of the seven largest Western, industrialised nations. The energy policy objectives agreed upon in all these various fora have usually focussed on increasing energy efficiency and replacing oil with other energy sources. Given the limited and depletable nature of oil resources, industrialised countries have seen a particular need for improving the efficiency of oil use. Better efficiency is clearly required since the world market now places a much higher value on these resources. Thus, oil should be directed towards those end use sectors where substitution is not currently feasible, i.e., the transport sector and the petro-chemical industry. Increased efficiency of oil use in industrialised countries would also contribute to reducing worldwide demand, as well as possible supply and price problems whose effect may be particularly damaging to the economies of developing countries. Therefore, energy policies in industrialised countries now aim at achieving structural changes in their energy economies to reduce dependence on oil in several ways. These include promoting oil substitution, as well as rapid expansion in the production and use of coal, natural gas, nuclear power and other available energies.

Regarding energy demand management in particular, the fourth of the IEA Principles for Energy Policy urges a strong reinforcement of energy conservation policies. The purpose of these policies is to limit growth in energy demand relative to economic growth, to eliminate inefficient energy use, especially of rapidly depleting fuels, and finally to encourage substitution for fuels in shortest supply.

At their last meeting in May 1983, IEA Ministers confirmed that these common objectives of international energy policy continue to be valid. They agreed that the current easing of the world oil market was no reason to change the principles, given the remaining uncertainties about short-term developments and the underlying trends pointing toward tighter market conditions in the longer term. The Ministers therefore reaffirmed the objectives of improving overall energy efficiency and bringing about a better balanced energy mix. The Heads of State and Governments at the Summit meeting in Williamsburg also confirmed this agreement.

II Structural change in OECD energy economies

Developments in the world oil market since 1973 have had strong effects on the economies of OECD countries in general and on the structure of their energy economies in particular.

Following the first oil price increases which occurred in 1973/74, the nominal price of oil did not change for some time but the "real" price after allowance for inflation fell steadily, until the second "oil shock" caused by the Iranian Revolution in 1979. Between the end of 1978 and the end of 1980, prices rose by a further 170%. Thus, in just a decade the price of oil rose from $1.60/bbl to nearly $35/bbl at the end of 1982, a more than twentyfold increase in money terms and sixfold in constant dollars. Since then prices have of course again been slipping back, both in nominal and more particularly in real terms, but still remain much higher than before.

As a result of these price developments and other factors, including the economic recession, a number of important structural changes have occurred in OECD countries:

- First, the overall efficiency of energy use and of oil use in particular has improved considerably. From 1973 to 1982, total energy use relative to GDP has fallen about 15%, and oil use relative to GDP about 29% in OECD countries.

- Second, overall dependence on imported oil in OECD countries (as measured by the share of imported oil in total energy use) has decreased from 30% in 1973 to about 26% in 1982. This trend is continuing as oil is gradually replaced by other fuels and the efficiency of its use continues to improve. Nevertheless, oil is expected to remain one of the major energy sources for the remainder of this century.

- And third, structural progress is not limited to the energy demand side alone. Domestic energy production in OECD countries increased by 400 million tonnes of oil equivalent (or about 8 mbd) between 1973 and 1981. Two-thirds of this increase are provided by additional production of coal and nuclear energy, reflecting efforts to achieve a better balance of the different energy resources in our economies.

The major factors that have led to these structural improvements of energy economies were the response to the price increases of 1973/74 and 1979/80 and the strengthening of energy policies in all OECD countries. Another important factor in the reduction of energy and oil use was of course the break in economic growth which was itself in part a consequence of the energy price increases. We believe that the expected revival of economic activity will entail a significant rise in overall energy demand.

It must be noted, however, that these structural improvements could only be realised at high economic costs. Indeed, the world economy was unable to absorb the oil price increases undamaged. They have contributed to

- the high increase of inflation in the OECD, particularly in 1980 and 1981;

- to the disruption in economic growth;

- and finally to the increase of unemployment in OECD countries from 19 million in 1979 to more than 32 million today.

This illustrates the dimension and the difficulty of the task to adapt our economies to a better balanced and sustainable energy future.

III The role of improved energy efficiency

The OECD expects an increase of overall energy demand in its area of about 40% by the year 2000. This increase will have to be covered by other energy sources than oil. If the necessary policies are pursued and the required investments are taken, energy supply patterns could look as follows by 2000: oil 30-35%, coal 30-35%, gas 18%, nuclear 11% and renewable energies and hydropower 6%.

Continued efforts in the area of energy demand management will have to play a major role in reaching this balance.

Indeed, current projections of Member governments for energy and oil requirements by the year 1990 assume continued improvements in the efficiency of energy use and an acceleration of the rate of decline in oil intensity, compared with results actually achieved from 1973-81. The most notable gains in overall efficiency are expected to occur in Canada and the United States. Results in these two countries were relatively weak up to 1979 but improved markedly following the decontrol of oil prices in the United States. In both the European and the Pacific regions of the IEA, the rate of overall efficiency growth is expected to continue, but at a slower pace in the 1980s than has been experienced since 1973.

The importance of efficiency improvements in meeting future energy objectives can be seen in countries' current projections. If the improvements projected for 1995 by IEA Members for the energy to GDP ratio do not occur -- for example, if the overall energy intensity of their economies remains at 1981 levels -- total energy use would rise more than 15% faster during the 1980s and reach a level 660 Mtoe higher than is now projected for 1995. Similarly, if the intensity of oil use in the economy were not to decrease from 1981 levels, oil use would reach a level 820 Mtoe (almost 17 Mbd) higher than is now projected for 1995.

IV Industrial energy consumption in the OECD from 1973 to 1981 and forecasts to 1990

Industry is the largest energy-consuming sector in the OECD area, accounting in 1981 for 37% of total final energy requirements, 22% of total primary oil use and 44% of electricity consumption. Over the period 1973-1981, industrial energy consumption decreased at an average annual rate of 1.5% (though during the period of economic recovery, from 1975-79, it grew by 4.3% per year).

For the period 1981 to 1990, OECD countries project a strong increase of industrial energy consumption by an annual average of 4.2%, reflecting expected economic growth. Over the same period, however, industrial oil use is expected to decrease, as it has in the period 1973-81. As a consequence, the share of oil in OECD industrial energy use is expected to fall from 38% in 1981 to 34% in 1990. Coal and electricity will be the main sources of substitution.

Significant progress in industrial energy efficiency, as measured by the overall energy/output ratio, has been achieved. Energy and oil use per unit of total industrial output declined by about 22% and 31% respectively from 1973 to 1981. Thus, in industry, as well as in other energy use sectors, historical links between industrial output and energy and oil use clearly have slackened. The results vary significantly, of course, by country and by industry. Our analysis shows that this progress was a result not only of the price increases for oil and energy, but also of general improvements in industrial productivity and the penetration of new technologies. Indeed, policies which encourage industrial investment are essential for improving energy efficiency because new production equipment and methods generally are more energy-efficient than the old ones.

On the other hand, not all of these improvements can be attributed to permanent progress in energy efficiency, in particular to the installation of more energy efficient equipment. Much of the reduction in specific industrial energy use is explained by shifts within the industry sector towards less energy-intensive industries, such as electronics, and by the continuous slump of output in some energy-intensive industries, particularly iron and steel. While total GDP of IEA countries rose by 20% from 1973 to 1981, industrial production increased by only 13%. Overall energy intensity has thus fallen in part because some industrial sectors with relatively low energy intensity have increased their share in total industrial output.

V Policies for energy demand management

IEA governments agree that appropriate energy pricing policies must be the basis for consistent energy policies. In industrialised countries, increases of energy costs generally provide the most effective incentive for consumers to use energy more rationally and to switch away from more expensive energy sources. Considerable progress has been achieved in this area, particularly with deregulation of oil prices in the United States.

But although proper pricing policies are recognised as the basis for sound energy policies, most governments also agree that markets often function imperfectly. And even where they do function well, the outcome can conflict with other social objectives and must be balanced against them. For this reason, most OECD governments assume that they have a legitimate role and a necessary responsibility to improve and supplement the operation of market forces where necessary to achieve energy and other policy objectives.

Some of the constraints that hamper improvements of energy efficiency, in particular in industry, are:

- First, economic and financial constraints such as difficulties of capital availability or poor cash flow position of potential investors. Internal "competition" of conservation and fuel-switching projects with other types of investments is often not carried out on equal terms;

- The second constraint is lack of adequate information and lack of awareness of both energy problems, energy costs and technical saving opportunities, especially in less energy-intensive industries and in small companies;

- Finally, other economic and institutional constraints are common such as those which are frequently encountered by increased waste heat utilization and combined heat and power production (CHP).

In addition to appropriate energy prices and taxation policies, many countries apply a variety of policy measures to cope with these problems. The most important types of such policy measures are:

- Fiscal and financial incentives to encourage research, development and demonstration (RD&D), commercialization and investment in energy-saving techniques. Most IEA governments provide a number of tax-credits, grants, low-cost loans or other aids to their industries in order to give them an increased economic incentive to invest in energy efficient equipment.

- Many countries use voluntary or (exceptionally) mandatory reporting and auditing schemes, often in combination with target setting for energy saving in industry, as well as the exchange of information gathered from such schemes;

- Many governments have also embarked on the removal of institutional constraints, e.g. to the increased use of CHP production through legislation or voluntary arrangements among industries and utilities concerned.

We will hear more about these policies in the course of this seminar.

International co-operation in this area has focussed on information and education in this area and on co-operative Research, Development and Demonstration activities. The IEA, for instance, launched an International Energy Conservation Month in October 1979 and the International Energy Management Initiative in 1980. Both activities aimed at improving national and international awareness of the energy problem, of the need to improve energy efficiency and at establishing an increased exchange of experience on practical opportunities and solutions.

VI Conclusion

Despite the considerable progress which has already been achieved in industrial energy efficiency, substantial scope still exists for further improvements. Our review of a number of government projections and other studies indicates that, between 1980 and 1990, energy savings in industry could amount to approximately 15 and 20% of present consumption. Savings potentials for the period 1980-2000 may be up to 30%. The potential varies from country to country and is different in each case, depending on factors such as the existing base level of energy efficiency, energy price levels, and, above all, the cost-effectiveness of potential efficiency investments.

Whether this conservation potential will effectively be used, and to what extent, will depend on future economic growth and industrial investment activities. Progress will also hinge on the preparedness of industries to consider, more than they have done to date, the value of a secure long-term energy supply, rather than apparent short-term advantages of minimum energy costs.

Continuous progress in improving energy efficiency and interfuel substitution will have to play a major role in achieving stable balances in energy markets and in reducing excessive dependence of OECD countries on oil. In the present easy situation of the oil market it will be particularly important to maintain the momentum towards structural improvements in our energy economies. Successful exploitation of these opportunities will help ensure that energy does not again become a constraint to further growth of the world economy.

Considerations for Rational Use of Energy in Latin American Industry

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1. Introduction

From the time of the Lima Agreement in November 1973, on up through the Pronouncement of San Jose in July 1979, and the Latin American Energy Co-operation Programme (PLACE) in November 1981, the Ministers of the OLADE Member States have insisted on the need to rationalize energy production and consumption (1).

In speaking here of rationalizing the production and consumption of energy, we are not referring to a reduction in national production or consumption. To propose the rational saving of energy in low consumption societies is equivalent to proposing that economic and social backwardness be maintained for peoples who have neither the possibility nor a moral obligation to the world, to reduce their consumption

By rationalization in Latin America, we understand in this paper the political, technological and organisational process by means of which a country fits the production structure of its energy sector to its resource endowment and to elementary efficiency criteria, and its consumption patterns to its supply structure, to its level of development and to principles of fairness, so that the limited amounts of resources available to it can satisfy the needs of its own economy and can assure for each citizen the minimum quantity and quality of energy necessary for the productive integration of society.

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(1) See OLADE. "Lima Agreement", "Pronouncement of San Jose", pp. 4 and 6; OLADE Latin American Energy Co-operation Programme, pp. 6 and 19.

Defined in this way, energy rationalization covers four fundamental aspects. First of all, conservation, in order to obtain a greater output from each unit of energy utilized, or less consumption per unit of production or well-being. Secondly, adjustments of the energy system to the national or regional resource endowment through an appropriate combination of sources; and this appropriate combination may or may not entail the direct substitution of one source for another. Thirdly, the just sectoral and geographical redistribution of energy consumption, in order to make it compatible with the development objectives and the prevailing criteria of social equality. Fourthly, the gradual shift of the economy towards a development style compatible with the true potential of the region and its countries.

In order to comprehend this concern, it is useful to analyse regional energy development as of 1973, when the first increases in international oil prices began to modify the world panorama.

During the 1973-1982 period, Latin America's energy consumption experienced a very satisfactory growth rate, if judging by the experience of other groups of countries and of the world as a whole. Indeed, during this period regional consumption rose to a cumulative annual rate of 3.4%, i.e., five times that of the United States and Canada, four times that of Western Europe, and three and a half times the rate of expansion of world energy consumption. Even though this growth began to slow down beginning of 1979 it was in the order of 2.0% during the 1979-1982 period, higher than the worldwide rate, four times higher than that of the planned economy countries, and markedly in contrast to the negative evolution recorded in industrialized countries.

Nevertheless, despite the dynamism attained and the progress made in periods in which the international economic crisis has hit the region hard, total energy consumption per inhabitant was only 1050 KOE in 1981, less than one fifth that of the OECD countries. Furthermore, if biomass were excluded in its traditional forms (firewood, bagasse, etc), the 1981 per capita consumption of commercial energy would be barely 830 KOE, less than one sixth of the average of the industrialized market economy countries.

Thus, to maintain a rapid growth of energy consumption constitutes an imperative for development and social progress in Latin America. It is not a simple imperative. In order to maintain constant consumption growth, massive action is required to increase supply, whether through domestic production or imports.

Between 1973 and 1981, Latin America's commercial primary energy production grew at a rate of 3.9%, a very acceptable pace if compared with the rates of world expansion and those of the groups of industrialized countries. Furthermore, due to the Mexican oil production of the 1979-1982 period, when world production and that of most of the world regions and groups of countries was dropping, that of Latin America grew at a rate of 7.2%, the highest in the world.

However, in order to maintain this rhythm of expansion of capital-intensive production when foreign exchange is scarce, Latin America has had to make major efforts. In most of the regional countries, net energy importers, the foreign exchange to import fuel competes with that needed to rapidly expand internal energy production (2). For these countries to maintain a rapid expansion of their national energy systems in a period of growing international inflation, and declining international prices for their raw materials, has required sizeable flows of external capital.

Now suppose, as a simple exercise, that the energy demand would no longer grow at the historical rate of 3.4% of the last ten years, but rather at a cumulative annual rate of 7.3%, i.e., at a per capita rate of 3.5% for consumption growth per inhabitant. With this rate of growth, extraordinary

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(2) Among the oil importing countries of Latin America in 1973, the energy bill accounted for 10% of their revenues from exports; in 1983 this figure hit 34%. For some of them the cost of imported energy consumes more than half of the value of their exports. In that regard, it should be noted that the Panama, Central America, and some Caribbean countries enjoy soft financial conditions for their petroleum purchases, through the Mexican-Venezuelan Co-operation Agreement and the Trinidad and Tobago Oil Facility.

but unreal, Latin America would still need to wait until the year 2000 in order to attain the 1980 per capita consumption levels of Spain, one the European countries with the lowest per capita consumption rates. Here it is worthwhile to note that Latin America does not expect to equal the per capita consumption of the industrialized countries, for it would entail substantial changes in its development styles.

The current objective incapacity of Latin America to overcome, in the short term, its low levels of consumption, while maintaining high rates of growth for the same, and the costs and constraints for the expansion of production at rates much higher than the historical ones, demand that each unit of available energy be utilized and that each unit be produced in the most rational way, so that a limited energy supply could be supported by efforts geared to development and social justice, and so that production inefficiencies would not become a stumbling block to the sector's development and thereby to the economy as a whole.

The energy challenge of the region is therefore evident. On the one hand, it is necessary to maintain a high rate of production and consumption. On the other hand, each unit of energy must be produced and consumed as rationally as possible. This dual challenge appears clearly outlined by the XII Meeting of Ministers held in Santo Domingo, as noted in the basic document of the Latin American Energy Co-operation Programme, which reads as follows: "the fundamental objectives of the PLACE consist of linking the production and use of energy to the goals of autonomous, sustained development; expanding and diversifying the energy supply and the scientific and technological capacity, and rationalising energy production and consumption (3).

2. Global Energy Production and Consumption

Before embarking on an analysis of energy consumption in Latin American industry, and the efforts made in the region to rationalize the production and consumption therein, it proves useful to study, somewhat superficially, the energy structure within which industrial consumption is found.

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(3) See OLADE. Latin American Energy Co-operation Programme (PLACE), Santo Domingo, 1981 - pp. 6.

Both the energy production and consumption of Latin America rest on oil. The regional economic structure has been oriented fundamentally towards the internal adoption of production patterns from the developed countries. Thus, industrial development has been based on a massive and indiscriminate use of oil, which was consummated by its low prices to stimulate energy development incongruous for the endowment of natural, human, and financial resources of this region.

Nevertheless, although in 1980 the share of oil in regional energy production went as high as 55%, as opposed to 16% for gas, 14% for biomass, 12% for hydro-energy, and less than 2% for coal, this share fell well below 64% in 1970 - not due to a drop in oil production, but to the national efforts at increasing the production of alternative sources (4).

Meanwhile, on the consumption side, the participation of oil was maintained between 45 and 48% over the last decade, although there are signs that this participation began to decrease as of 1980 as a consequence of the world recession and the impact of alternative sources on primary energy consumption structure. Indeed, hydro-energy (with 15%), gas (15%), and coal (3.5%) have started gaining a foothold in global energy consumption (5).

In order to evaluate the reaction of regional oil consumption to price increases, it is worthwhile to take the following elements into account:

In the first place, the Latin American countries, due to their low economic and technological levels, cannot reduce their energy consumption, except at the expense of lower economic growth rates. Due to the fact that their technological options are scarcer and their per capita consumption lower, they have little room to adopt energy conservation and savings measures. In other words, their energy demand is not elastic in the face of price variations.

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(4) Thus, during 1972-1982, the 2.8% cumulative annual growth rate for oil was a very satisfactory rate, judging by international indexes, but far below the 6.4% for coal, 6.6% for gas, and 9.5% for hydro-energy.

(5) See OLADE. Energy Balances for Latin America, 1980.

In parallel, up until the mid-1970s, the oil price hikes coincided with important increases in the prices of other basic raw materials within the economies of many of the regional countries. This permitted a certain amount of recovery in the terms of trade of those countries, thus alleviating the pressures on the balance of payments and on the fiscal economy, which, in turn, facilitated for the governments the handling of this crossroads situation.

In the second place, the transformation of the productive apparatus and of energy consumption takes time. For economies highly dependent on oil, the alternatives were to maintain imports or reduce consumption.

In the third place, Latin America is not only a net exporter of oil; three-quarters of its largest economies (i.e., Argentina, Mexico, and Venezuela) are self-sufficient or are oil exporters, as are four of the other economies (Peru, Ecuador, Bolivia, and Trinidad & Tobago). For these countries, the substitution or reduction of oil consumption for energy purposes and its use for "nobler" ends is, as in the other countries of the region, a national objective. Nevertheless, the emphasis on oil substitution has been lesser than in importing countries.

Moreover, the oil price increases led to increased exploration and exploitation. For the exporting countries, the economic prosperity generated by oil prices produced an immediate rise in energy consumption. Since they possessed oil, it was obvious that this sudden increase in demand would be satisfied with hydrocarbons, and not with alternative energy sources. It would take some time before these economies would react and use part of their income from oil to change their internal energy structure.

With respect to the sectoral distribution of energy consumption in Latin America, this shows quite significant changes, which reflect the evolution of the regional economy itself. During the decade of 1960s, the industrial sector held first place as the largest energy consuming sector, with 34% (6).

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(6) This regionally valid criterion ceases to be so without the participation of Argentina, Brazil and Mexico, so that the residential, commercial and public sectors would be the main consumers.

The residential, commercial and public sector, to the contrary, lost some of its share, going from first place to third.

While the growth of industrial sector participation represents a very positive trend in a developing region, the same cannot be said for the growth of transportation consumption. The latter reflects very well the major contradictions in the economic development of Latin America; consequently, the rapid growth of its consumption can equally represent the dynamization of production or waste. In any case, this rapid growth of consumption in the transportation sector explains the important share maintained by oil in regional consumption structure. The sector depends almost exclusively on oil derivatives and absorbs nearly two thirds of all of the oil consumed in Latin America (7).

It is worthwhile to note that the divergence between the tendency of the various sources to participate in production structure and in consumption structure is of temporary nature; and it reflects the type of assymetry that must be brought about by the energy transition. However, Latin America's energy production and consumption is undoubtedly oriented towards a combination of sources more in keeping with regional energy potential.

3. Energy in the Industrial Sector

During the last decade, the consumption of the industrial sector grew at a cumulative rate of 6.7%, going from 46,400 TOE in 1979 to 88,400 TOE in 1980 and therefore increased its share in final energy consumption.

Contrary to what is happening in the industrialized countries, existing data show that the energy intensity of the Latin American industrial sector is increasing slightly. This trend is logical, since unlike mature economies, they are entering upon the development stage of large iron and steel, cement, and petrochemical projects, etc., which are energy-intensive. It is plausible to suppose that, despite the crisis, emphasis on the development of industry

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(7) See OLADE. "The 1982 Energy Situation of Latin America", pp. 45.

will continue during the rest of this century, with its subsequent implications for the energy intensity of the sector.

3.1 Energy Optimization in the Industrial Sector

By optimization, we understand herein the group of measures geared to upgrading efficiency in use, whatever the source may be. As has already been explained, energy conservation does not mean a simple reduction in consumption, entailing a reduction in the levels of production or well-being, but rather a more adequate use, in order to maintain the same levels of production or well-being and even to improve them while consuming less energy.

In Latin America however, it can be pointed out that the systematic effort to adjust the energy structure to national resource endowment has entailed, in practice, a set of actions to substitute oil or to reduce its participation in future energy demand. The actions conducive to improving efficiency in the production and use of energy seem to have, still, a sporadic nature and little impact in terms of recent application.

It seems that, although to a lesser extent than in other sectors, the reaction of energy consumption in the industrial sector to oil price readjustments has been slow. With few exceptions, until the second hike, national efforts undertaken to use energy more efficiently were negligible. In fact, in 1979 when the oil price increases began to pick up, many countries discovered that their state organisation did not have suitable mechanisms to manage a sector whose impact on the economy was already a determining factor. It was then that the problem of energy management began to be important enough to require governmental attention; and, likewise, it was after an adequate conceptualization of the energy sector that the concept of energy optimization acquired a certain amount of relevance.

One of the consequences of this lack of interest in conservation programmes is the lack of statistics on energy consumption by the various branches of industry, to be fed into a national information system on energy use. The national data available are limited to isolated studies on given branches; but in these isolated studies, important potentials can be observed for a serious paper on conservation.

The only exception of systematic work to be had in Latin America could be that of Brazil, where the State has been working since 1978. In one study on consumption and energy behaviour in the industrial sector, which included more than 2,200 firms, the National Petroleum Council of Brazil found that in 1979, the potential for energy economy in the companies studied was 26% without any need for important changes in processes, i.e. on the basis of more careful administration of energy and certain technical adjustments.

After one year of work on conservation, the potential had dropped by 6.2% whereas energy efficiency had improved by 7.2%, proving that once the rationalization process begins, new conservation possibilities tend to appear, until a threshold is reached.

One of the results of Brazilian surveys was that energy consumption is concentrated in a few branches of industry and within these, in a very small number of firms. Some two hundred firms consume 65% of the energy in the industrial sector, and the 1000 companies having the largest consumption absorb 90% of the energy destined to industry.

The result of these studies and of Brazilian conservation measures even when the peculiarities of that nation are considered, seem to confirm the existence of a conservation potential in regional industry and a real possibility for tapping it. They also confirm that the initiation of a conservation programme can prove feasible when a relatively small number of firms concentrate a high percentage of consumption. From Brazil's experience it could also be concluded that in the regional economies, some few dozen firms carry the same weight, percentage-wise, within energy consumption. The concentration of efforts in these few enterprises, even with limited resources, could make it possible to launch a first stage of a national energy conservation programme in the industrial sector.

One of the most relevant elements of the Brazilian process has been the firm participation of the State in creating mechanisms that will arouse interest and willingness in thousands of actors in the rationalization process. Without such State participation, the internal structure of the Brazilian economy would have discouraged this process.

3.2 Energy Consumption in the Industrial Sector

The composition of industrial sector consumption underwent important modifications during the last decade. Electricity and coal increased their participation at the expense of oil and biomass.

Latin America: Percentage Distribution of Industrial Sector Consumption by Source

	1970	1980
Coal and Coke	8.4	9.1
Biomass	10.4	9.5
Gas	20.6	22.8
Electricity	10.2	14.3
Others	4.1	3.5

Source: OLADE.

These modifications, however, constitute the beginning of a process to restructure the energy profile of Latin American industry, where despite the difficulties, some countries are already making important efforts at using other energy sources in industry.

Biomass, which was the number one source of energy in regional industry, is being recovered in order for it to be converted into an energy form of broader use. In several countries, actions are being undertaken to improve charcoal production and to use it in the mining and metallurgy industry and in cement production -- in some cases directly and in others, mixed with coal or fuel oil.

In the sugar industry, where bagasse was substituted for oil, the former is not only used again for auto-generation of steam and electricity; in many sugar-producing countries of the region, projects have been carried out, or are now underway, to use bagasse more efficiently so that the surplus can be used to generate electricity in other industries. In Brazil, the energy consumption of ethyl alcohol went from 0.5 million cubic meters in 1976 to more than 4.0 million in 1982, replacing the equivalent of 53,000 barrels of oil per day in transportation.

Other biomass elements which had been neglected, such as the residues from rice mills and sawmills, are being tapped to satisfy the energy needs of the very industries that generate them. Likewise, rice, straw and other wastes are finding uses in the cement industry.

As for coal, the development of non-ferrous mineral industry and the conversion of cement plants are bettering its share in industrial sector consumption. The process is slow and it is concentrated in the largest countries of the region.

Furthermore, the use of natural gas is growing. The ease of its handling and its availability in the region's oil countries will permit its more intense use in the future.

Finally, electricity, with an impressive amount of possible uses, is being exploited by industry to substitute those forms of energy that are scarcer or harder to handle. To the traditional use in generation of electromotive power can now be added electrothermics in boilers, ovens, dryers, and other industrial elements. Inspite of the fact that during the last two decades production grew at a cumulative annual rate of 8.8%, the per capita electricity consumption of Latin America barely surpassed 2000 kWh, which demonstrated the fact that there is an immense capacity for potential use in the region.

The interest in electricity is not only due to its diversity of uses but also to the diversity of primary energy sources of national origin from which it can be generated. This diversity can be noted in the changes observed in the composition of sources used in electricity production during the 1979-1980 period. Hydro-energy has gained a large share over thermoelectricity and already by 1980, 58% of electricity was hydropower. It is estimated that for 1982 this participation exceeded 60%. Other sources, biomass, geothermal and nuclear power, have a very small participation in regional electricity production.

Latin America: Electricity Production

(Millions of kWh)

	1970		1980		Growth Rate 1970-1980
Thermal	78,630	0.49	154,260	0.41	7%
Hydro	81,450	0.51	214,348	0.58	8%
Others	46	0	3,630	0.01	___
Total	160,126	100	372,238		8.8%

Source: U.N. Yearbook of World Energy Statistics, 1979, 1980

These figures however, do not reflect the changes in the composition of sources that is now occurring in the region, since long lead times and execution periods have kept the large projects initiated in the last decade from having much impact on the balance (8).

Despite the difficulties in obtaining funds for hydroelectric projects, there is no doubt that this source will play a very important role in Latin American energy structure by the turn of the twenty-first century. The low per capita, electricity consumption indexes, the sparse coverage of such services within the region, the possibilities for intensifying the use of electricity in industry and transportation, regional experience in planning and executing hydro power projects and the Latin American capacity for producing capital goods for this type of project, have made hydro-energy one of the strategic cornerstones of regional energy development (9).

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(8) See OLADE. "The 1982 Energy Situation of Latin America", pp.21.

(9) See OLADE. "Hydro Power: Energy Alternative and Industrial and Financial Challenge for Latin America", 1981.

In addition to the efforts made to substitute oil by hydroenergy, the actions of Brazil and Colombia in using coal for electricity generation deserve to be mentioned. In some Caribbean countries there exist projects to convert oil-based thermal plants to coal and to expand the electric power system on the basis of this source. Colombian coal projects are increasing the feasibility of the national programmes.

In El Salvador and Mexico, important geothermal projects are underway. In other countries such as Nicaragua, progress is being made in the formulation of geothermal-based electric power projects (10).

3.3 Rationalization of Consumption Distribution

Energy being an indispensable element in a country's economic and social development, and given the low levels of consumption and the difficulties in overcoming these levels in the short term, energy distribution constitutes one crucial component in the rationalization problem.

In so far as this aspect, the Ministers of Latin America have noted that "The increases in supply should be destined to meeting real development requirements, not to covering unnecessary consumption, within the region or outside it" (11).

There are two aspects to rationalizing distribution which must be considered. First of all, the distribution of available energy among the different consumption sectors and sub-sectors should follow an order of priorities defined by the country's requirements and level of economic development. Both energy production and importation require sizeable amounts of scarce resources. In the Third World countries, these resources earmarked for energy have to be distributed among different sectors so as to accelerate national development and to provide each one of the social groups with the energy needed to satisfy its basic needs. Moreover, it is important to promote energy planning and policy-making systems making it possible to attain the objectives laid out.

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(10) See OLADE. "Energy Bulletin" Numbers 20 and 22.

(11) See OLADE. "Pronouncement of San Jose", 1979.

Second, the process of energy rationalization consists of distributing energy supplies in accordance with the regional development strategies of each nation. Even when data are scarce, they seem to point to the fact that the distribution of the energy supply is a factor that has been providing incentives to the process of the economic and population concentration that characterizes Latin America.

As has already been seen, the assessment of energy consumption by sectors shows encouraging signs in terms of the participation of the productive sectors in global consumption, even when this improvement has not been the result of a deliberate rationalization process for distribution.

Furthermore, while the distribution of consumption has not been explicitly dealt with in the region, many of the measures taken by the countries point in that direction. The tariffs system and the price differentials for hydrocarbons reflect an intention to favour given consumption sectors and sub-sectors and/or to penalize others. The systematization of this process of discrimination will hav to form part of the energy rationalizatian policies of many of the Latin American countries.

3.4 Changes in Development Style

For Latin America, one of the major accomplishments of the oil price hikes was the radical questioning of an imported dependent development style wherein production and consumption structures did not correspond to resource endowment and income levels.

Now it must be sought to readapt the economy and lifestyles to the internal possibilities of the region and the regional countries, i.e., the region must "find itself" and learn about its own reality through the global process of rationalization of the whole economy. This process will necessarily have to be slow and complex, and rationalization of energy production and consumption will be a fundamental element.

4. Economic Structuring and Rationalization

As of 1973, with the joint decision of the oil-exporting countries to reassess a non-renewable raw material, which until then had been the basis for sustaining a wasteful energy development style, an era began in which solutions must be found towards a transition to other new and renewable sources.

The repercussions of the oil price hikes occurring in the past decade have made the countries become increasingly aware of the importance of the conservation and substitution of a resource that tends to become depleted; thus, the imperative to seek energy planning schemes geared to eliminating the uncertainty brought about by pricing within a "free" market structure. At the same time, the oil price increases have provided an argument to the industrialized countries to blame the exporters for the current economic crisis, though the ill-termed "energy crisis" is only one of the manifestations of the same and of the development style followed, which gave rise to important deformations in Latin American production structure.

The inter-relationship between economic activities and energy is necessary in developing an effective policy to rationalize energy production and consumption, since the possibility of energy rationalization for a sector must be sought within a process of rationalization of societal life.

On the other hand, while the industrialized countries are the major hydrocarbon importers, the effects of the so-called "energy crisis" are lesser for them than for under-developed countries, since they have more diversified energy balances; moreover, their economic and technological capacity permits them to cope more easily with the oil shortages and oil price increases.

If these ideas are borne in mind, one can analyse the responses given by the OECD countries as regards oil prices; and one can discover that these responses have no novel elements. They are typical reactions from economies that have managed to accumulate immense amounts of capital and technical knowledge, that possess very diversified productive structures, and that have the capacity to react to changes in terms of costs and prices. This reaction, in its potential economic and technological aspects, would be produced in the face of any similar situation with any other basic raw material.

4.1 Energy Rationalization in Latin America

The regional situation is quite different, and these differences should be grasped in order to formulate policies which, based on Latin American reality, will make it possible to surmount the frustrations generated by imitative solutions. Furthermore, these differences have to be understood in order for the advances made by the region to be adequately assessed in the process of energy rationalization. The reaction of an economy to price changes for a basic input fundamentally depend on the productive structure and on its sensitivity to changes in costs. The necessary protection of a national enterprise in the face of competition from trans-national monopolies, price controls established to make certain inequalities less serious and State industry itself have not evolved suitably to sustain their own objectives within acceptable levels of efficiency. The slight emphasis of the State on attaining more effective functioning of the markets has not only jeopardized the necessary assessment of these basic instruments for the development of Latin American economies, but has also permitted that cost increases be passed on automatically to the consumer, without the producer feeling obliged to generate innovative responses allowing for reasonable adjustments to the new situation.

Under these circumstances, pricing policies, being an essential element of energy policies, prove to be quite limited; they should be designed with the utmost care in order to avoid becoming new elements of distortion in the regional economies.

Furthermore, the region suffers from serious financial constraints. As of the end of the fifteenth century, Latin America became one of the major producers of wealth in the world. Unfortunately, that wealth has always belonged to someone else, thus creating the paradox of a region wherein the more it saves, the less it accumulates, since the sacrifice of its peoples is transformed into earnings abroad.

Even though there are significant prospects for rationalization, without large investments, it is unquestionable that for the region this financing constitutes a real obstacle for the execution of important conservation projects.

As for substitution, we should not lose sight of the fact that such a process can be capital-intensive. The investment made in substituting one gallon of oil per year by means of hydro-electricity requires between 250 and 300 dollars for generation alone, i.e. without including the investments it would be necessary to make so that industry would be able to use that electricity instead of oil or oil derivatives. To substitute oil by coal, gas or biomass can require investments of different magnitudes, but in all cases important ones, and the investment projects in this field will have to share the scarce funds available with other projects. This makes it difficult and complex to finance the investments that will be required for substantial changes in the industrial park.

The financing problem becomes even more acute due to the levels of debt of the regional countries. The payment of the debt and the limitation of capital flows will also create new restrictions for the rationalization process.

Likewise, Latin America groups economies of different sizes and different degrees of development and, of course, diversification, with a low level of integration among them. For our economies, conservation and substitution can become dynamic elements in investment and domestic production. The hydro-energy, coal, and biomass development projects of Brazil, to cite just one example, have been able to take place with a very high participation by Brazilian technology and industry, and have turned themselves into important driving forces not only exclusively for energy development, but for overall national development as well.

It should also be pointed out that while Latin America possesses large and varied energy resources, their distribution is quite uneven; and this obliges the design of different substitution schemes to orient them to national energy structures.

Some countries do not have enough resources or the available resources cannot be developed rapidly; thus they find it necessary to continue importing energy. As has been said, these imports compete for the funds needed for internal energy development and complicate the search for an optimal combination of national and foreign resources which would aid in attaining national objectives. In this regard, the Mexican-Venezuelan co-operation programme for energy financing in Central America and the Caribbean, and the Trinidad & Tobago oil facility for some Eastern Caribbean countries, offer examples of co-operation that should be equalled in other parts of the world.

Finally, although a broad gamut of technologies exists, and although others are being developed for energy conservation or substitution of sources, many of them are not available to all of the countries of the region or they require resource endowments quite different from those of these nations.

Hence, most of the energy technologies developed in Europe and Japan, to conserve or substitute energy, tend to replace energy by capital through processes progressively more refined and costly. For a region with financial difficulties, a capital-intensive technology can cause more problems than it solves.

4.2 Final Reflections

The problems of market structures, financing availability and energy resource and technology distribution lead to some final reflections as to the process of energy rationalization in Latin American industry. It seems obvious that the development of a rational combination of sources will not be a simple process. On the substitution side, successful efforts at developing alternative energy sources have required enormous amounts of resources to supplant oil.

On the conservation side, the potential in the industrial sector and in other consumption sectors does not matter; the process has a technological limit and an economic limit, as of which point consumption leads to a reduction in, or higher price for, production and well-being. The expansion of industrial production requires energy; and while a conservation programme may well reduce the industrial growth rate and even industrial consumption, it is a temporary phenomenon, which will gradually disappear to the extent that the programme successfully matures.

The energy density of the industrial sector can be reduced but not the fact that industrial production requires energy and that a growing industrial sector must raise its energy demand.

Thus, it can be concluded that the decisive presence of oil in Latin America's energy supply and demand will continue for many years to come. The countries that do not possess oil will have to act in light of this reality.

Moreover, the conservation and substitution projects have to be viewed with the same objectivity as that called for by energy development projects, with due attention granted to the place where these projects can create progress and where ties of dependence can be destroyed or generated. As pointed out previously, not all the countries can utilize investments in the same way to change a process or to develop substitute sources. If the projects ae not chosen on the basis of their national repercussions, they can have fewer effects in the countries that execute them that in those that contribute the equipment and technology. Both conservation and substitution can be effective instruments in decreasing dependence, but they can likewise increase it. A project can reduce the consumption of imported energy or can substitute it by national sources whose development can have major internal repercussions. Another can reduce or substitute energy that is not readily at hand, by capital and technology that is not to be had either, shifting the country's dependence from an energy supplier to a capital or technology supplier.

Finally, while in any type of economy, energy rationalization requires active participation by the State, in order to overcome market limitations as well as to provide orientation to the energy sectors, in societies such as those of Latin America, the institutional aspect ceases to be a complement and becomes an essential element in the process.

Without a clear and firm decision by the State, manifested in concrete actions to guide industrial firms, there is no possibility of developing a successful rationalization programme. In the case of the electric power sector, public support for the substitution of oil by other sources has indeed been clear and the results, evident. Nevertheless, in other branches of the sector, very few countries have concrete programmes capable of producing an impact; thus, the need to formulate integral programmes of action in this field.

Neither should we lose sight of the fact that although the region has sufficient natural and human resources, and has the basic technological knowledge to become involved in an important rationalization process, it seems quite difficult, under the present international circumstances, for energy rationalization to advance rapidly unless the spirit of Latin American co-operation is consolidated through specific projects. Together, the countries of Latin America will be able to surmount many of the constraints now suffered by the process; separately, each one of the countries will find stumbling-blocks difficult to overcome.

The foregoing reflections do not intend to be discouraging, but rather to put the process into its proper perspective. In all of the coutries of the regional there exists a potential for rationalization which should be tapped as part of the energy development strategies. However, we should not overlook the fact that while this is an important part of the solution to regional energy problems, rationalization is not a "cure-all" for these problems, and its features should be a function of the concrete realities of the region, in order to become an instrument capable of dynamizing the economies and aiding to pull them out of their states of dependence.

This does not mean that in its efforts to rationalize energy production and consumption, Latin America should act "behind the world's back". As the PLACE affirms, "The Latin American countries have to cope with the international economic and energy situation with their own, independent solutions. However, these efforts should be complemented through international co-operation, despite the difficulties derived from the prolonged crisis experienced by the industrialized countries. There is no doubt that intense international co-operation will be mutually beneficial for developed and for developing countries alike" (12).

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(12) OLADE. Latin American Energy Co-operation Programme (PLACE), Santo Domingo, 1981, pp. 273

ENERGY CONSUMPTION IN PERUVIAN INDUSTRY

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I. Frame of Reference

Peru is located on the West Coast of South America. It's territory has an area of approximately 1.3 million km^2. The current population is 17.8 million, with an average growth rate of 2.5% per year during the past decade. Approximately 45% of this population lives along the Coast, 50% in the Andean highlands (Sierra) and 5% in the Amazon (Selva). The corresponding areas are 12, 27 and 61%, respectively. The Capital, Lima, is on the Coast and its population borders 5 million inhabitants and is rapidly growing due to internal migrations. Peru's main industries are established in Lima, converting the city into Peru's economic heartland.

In 1982 Peru's GDP was US$ 19.2 billion which, in per-capita terms, amounts to US$ 1,068. Total exports were US$ 3.2 billion and the country's total debt is about US$ 11.6 billion.

Peru's manufacturing industry enjoyed a dynamic period during the 1950's as a result of import-substitution of consumer and intermediate goods. The growth of manufacturing industry and the sector's share of GDP is shown in the following table :

PERU : GROSS DOMESTIC PRODUCT

Values in Billion (10^9) 1973 Soles

Table I-1

	1950		1960		1970		1981 (*)	
	Value	%	Value	%	Value	%	Value	%
Manufacturing	22.9	18.1	49.5	22.9	87.2	24.7	123.5	24.6
Total GDP	126.3	100.0	215.7	100.0	352.6	100.0	502.9	100.0

(*) Estimated

Source : Reference 1-a

* Consultants to Project PER/82 - Technical and Economic Studies of Energy. UNDP - Ministry of Energy and Mines.

It can be concluded that Peru's GDP and Manufacturing output grew at the following average annual rates :

AVERAGE ANNUAL GROWTH RATES

%

Table I - 2

Period	GDP	Manufact. Output
1950/60	5.5	8.0
1960/70	5.0	5.8
1970/80	3.2	3.3
1950/81	4.6	5.6

Table I - 3 gives a break-down of gross output of manufacturing industry by branch for 1970 and 1981.

PERU : GROSS OUTPUT OF MANUFACTURING INDUSTRY

Values in billion (10^9) 1973 Soles

Cuadro I-3

	1970		1981 (*)	
	Value	%	Value	%
Food	31.4	36.0	30.1	24.4
Textiles	12.5	14.3	15.1	12.2
Chemical Prods.	10.8	12.4	22.8	18.5
Primary Metals	7.6	8.7	14.1	11.4
Metallic Prods.	7.9	9.1	18.2	14.8
Other Industries	17.0	19.5	23.2	18.7
TOTAL	87.2	100.0	123.5	100.0

(*) Estimated Source : Reference 1-a

During the period 1970-1981, the chemical, primary metals and metallic products were particularly dynamic, growing at an average rate of 7.0, 5.7 and 7.8%, respectively. The share of these three branches grew from 30.2 to 44.7% of total industrial output during the decade.

II. The Peruvian Energy System

Peruvian apparent consumption of primary energy, i.e. that demanded for internal consumption before transformation, reached 133,000 TCal in 1982, while primary energy production was 155,000 TCal. The difference between these two figures is accounted mainly by the export of crude oil (20,000 TCal). The break-down of apparent consumption in 1982 was as follows :

APPARENT CONSUMPTION OF PRIMARY ENERGY, 1982

Table II - 1

	TCal	%	Usual Units
Crude Oil and Associated Gas	86,700	65.2	62.8 10^6 Bbl
Hydro-energy	10,000	7.5	9.3 10^3 GWh
Animal and Vegetable Fuels	35,600	26.8	9.8 10^6 Ton
Coal	700	0.5	100.0 10^3 Ton

Source : Reference 1-b

The animal and vegetable fuels shown are mostly non-commercial fuels used in the rural sector (mainly firewood and cow-dung).

Hence commercial fuels represented 73.2% of apparent primary energy consumption while non-commercial fuels had a 26.8% share. The latter's share has steadily fallen over the past decades : in 1965 this share was 46.5%.

The production of commercial energy is mostly (92%) of non-renewable forms , the reserves of which are the most limited (Oil : 1'070,000 TCal, Gas : 160,000 TCal and Coal : 19,000 TCal), representing only 8% of total energy reserves. In contrast, the hydro potential, estimated at 58,000 MW, would mean 'reserves' of 16'000,000 TCal (assuming 5,000 hours per year and 50 years useful life). Biomass, uranium and other energy resources have not been considered in this comparison, despite their having great potential importance.

National crude output during 1982 reached 71.2 million Bbl, enough to satisfy domestic demand and generate exports.

Total refinery capacity in Peru is 187,500 bpd of which 173,000 bpd are installed on the Coast and 14,500 bpd in the Amazon.

Electricity production in 1982 was 11,328 GWh, of which 82% were of hydro origin and 18% thermal. Excepting the small use of bagasse as fuel (4% and diminishing) , thermally generated power uses mostly fuel-oil, diesel and gas. The 1970/82 growth rate of electricity output was, on average, 6%.

The installed capacity of power stations was 3,228 MW in 1982, of which 1,917 MW (59%) hydro and 1,321 MW (41%) thermal. Of total capacity, 65% belonged to public utilities and 35% belonged to self-producers.

National coal output in 1982 was 70,000 tons (anthracite); 30,000 tons of bituminous coal and 86,300 tons of coke were imported also.

Final energy consumption in 1981 was 99,700 TCal. This breaks down by economic sectors as follows : residential, commercial and public services : 42.7%, production (manufacturing, agroindustry, fishing and mining) : 32.0 %, transportation: 25.3%.

Per-capita energy consumption in 1981 was 6.3 G Cal and per-capita electricity consumption was 594 KWh, both below the corresponding world average values of 19.5 G Cal and 1,700 KWh. Almost 35% of Peru's total population consumes fire wood while only 40% has electric lighting.

We now consider the participation of the economic sectors in GDP and in energy and electricity demand. The production sector (manufacturing, fishing, agro-industry and mining) contributed with 53.8% to GDP, while demanding 32% of total energy and 67% of total electricity.

Peru's energy trade balance has been favourable for the past 5 years because of the growth of oil production at a rate sufficient to cover domestic demand while leaving an exportable surplus equivalent to 20% of total exports. Less t in 2% of energy consumption is satisfied by imports : mainly coke and coal.

The industrial sector's energy consumption in 1981 was 31,900 TCal, represen-ting 32% of the country's total. The sector's consumption is broken down as follows : manufacturing, 57% ; mining and metallurgy, 26% ; agro-industry, 10% and fishing (fishmeal included), 7%.

In the period 1970/81, the sectoral growth rate of energy consumption avera-ged 1.6% per year while gross output grew at yearly average of 2.8%.

Table II-2 shows the composition of industrial energy consumption by fuel :

ENERGY CONSUMPTION - INDUSTRIAL SECTOR
BY FUELS

Table II - 2

	1970		1981	
	TCal	%	TCal	%
Oil and gas products	17,200	64.2	21,200	66.5
Coal and coke	300	1.1	800	2.5
Electricity	3,100	11.6	5,400	16.9
Firewood and bagasse	6,200	23.1	4,500	14.1
TOTAL	26,800	100.0	31,900	100.0

SOURCE : Reference 1-b

From this data we see that oil is, not only Peru's predominant industrial fuel, but also its share in consumption has grown. The share of electricity has grown much more rapidly, along with that of coal and coke. The latter's share remains, however, negligible.

The manufacturing branches of industry, i.e. those comprised under Divisions 31 to 39 of the Uniform International Industrial Classification, registered an energy consumption of about 18,000 TCal, of which the following Divisions represented 77% : Paper ; Chemicals, Petrochemicals, Rubber and Plastic ; Non-metallic Minerals and primary metals (respectively, Div. 34 to 37).

During the period 1970/74 the prices of fuels and electricity in Peru were roughly constant in US$ terms. These prices began to increase after 1975 and now reach approximately international levels with the exception of electricity, as shown below :

ENERGY PRICES IN PERU

	Fuel	1970/74	May 1983
1.	Oil Product Prices (U.S. ¢ / gal)		
	Gasoline (84 oct')	21	103
	Gasoline (95 oct')	35	117
	Kerosene (Residential)	4	52
	Kerosene (Industrial)	10	86
	Diesel Oil No. 2	10	86
	Fuel Oil No. 6	6	74
	L P G	16	74
2.	Electricity Tariffs (Lima, in US ¢ / KWh)		
	Residential	2.6	2.8
	Industrial	2.7	4.5
	Commercial	6.7	10.6

Source : Authors' calculations.

III. Energy Use in Selected Branches of Industry

A. Steel

A.1 Branch Structure

The Peruvian Steel Industry is comprised by the State Enterprise SIDERPERU and the private firms Laminadora del Pacífico and Empresa Siderúrgica San Anto nio, both recently established. The latter produces construction steel and steel wire, while the former produces steel bars, with an installed capacity of 60,000 MT.

A.2 Processes, Installed Capacity and Production Levels

SIDERPERU's works are located in Chimbote and include the following plants : blast furnace, direct reduction, flat mill, non flat mill, foundry, etc. Annual capacity is about 520,000 MT of liquid steel.

The blast furnace has a diameter of 5.5 m with a useful volume of 540 m^3 and a capacity of 310,000 MT/year. The furnace processes the acid iron pellets produced at Marcona (Southern Peruvian Coast) and uses entirely imported coke. Part of the slag produced is sold to the cement industry.

The steel plants are equipped with 4 arc-furnaces with a joint capacity of 270,000 MT/yr. liquid steeel. Two 30 MT oxygen converter units are also installed, totalling a capacity of 330,000 MT/yr. liquid steel. Two contiunous castings are carried out yearly, each of 162,000 MT.

The direct reduction plant is designed for 100,000 MT/yr. sponge iron, using the SL/RN process in 3 rotary kilns. Acid pellets are used, together with coke powder or coal and powdered limestone.

A.3 Total and Specific Energy Consumption International Standards

SIDERPERU is one of Peru's main energy consumers, representing about 9.8%, of total manufacturing consumption or 5.6% of that of the whole production sector. The main fuels used are coke and fuel oil ; these represent 70% of energy consumption in SIDERPERU, as shown in Table A-1.

The specific energy consumption of liquid steel for 1980-81 is given below:

	Liquid Steel Production (MT)	Liquid Fuels (KCal/kg	Electricity (KWh/MT)	Coke (KCal/Kg)	Coal (KCal/Kg)	Energy (KCal/Kg)
1980	381.061	1611	707.8	2729	160	5109
1981	310.302	1929	799.5	2698	417	5732

We now compare theses values with those corresponding to other countries:

France	(1973)	4967 Kcal/Kg.
West Germany	(1974)	3988 Kcal/Kg.
Italy	(1974)	3558 Kcal/Kg.
Holland	(1973)	4800 Kcal/Kg.
United Kingdon	(1974)	4681 Kcal/Kg.

SOURCE : Reference (2)

The Peruvian values appear high in comparison with international standards and this is largely due to the fact that only 60% of installed capacity is being used.

A.4 Share of Energy in Production Costs.

This was nearly 27% in 1981, of which the cost of coke and electricity was the most important :

	Liquid Fuel	Electricity	Coque	Coal	Total
1981	5.0	9.0	12.0	.6	26.6

SOURCE : Reference (4)

A.5 Energy Saving Potential

Two important studies have been carried out on the energy saving potential in SIDERPERU (See References (3) and (4)). The main recomm ndations are :

(a) Short-Term :

- Increase the use of fuel oil in the blast furnace in partial replacement of imported coke. It would, however, be necessary to previously reline the furnace with refractory bricks.

- Increase the use of blast-furnace ga. in boilers.

- Reduce the considerable losses of steam in traps and by overall leakage.

- Carry out a campaign of inspection, installation and maintenance of insulating material throughout the plant.

(b) Medium and Long Term :

- Partial substitution of coke by anthracite.

- Increase in flame temperature by changes in fuel mix and dehumidification and oxygen enrichment of air.

- Recovery of LD-converter gases.

- Preheating of scrap iron with heat leaving ingots and billets during cooling.

- Complementary heating in electric furnaces, using fuel oil and oxygen, in order to reduce peak electric demand.

SIDERPERU has also finished a Rehabilitation Plan Study which includes certain aspects related to energy efficiency, a Plan which it is hoped will be put into practice soon.

ENERGY CONSUMPTION OF SIDERPERU

(1981)

Table A-1

UNIT	SOLID FUELS		LIQUID FUELS			Electricity (10^6 KWh)	TOTAL (TCal)
	Coke (10^3 TM)	Anthracite (10^3 MT)	Fuel Oil	Diesel Oil	Propane		
Blast Furnace	102.1	-	500	11.9	-		
Boiler House	-	-	1,547	76.5	-		
Direct Reduction	28.7	18.5	-	1,932.3	-		
Steel Melt Shop	-	-	226.8	532.1	80.1		
Lime Kiln	-	-	1,521.4	0.9	-		
Foundry	-	-	-	168.9	-		
Non Flat Mill	-	-	4,561.1	564.2	-		
Flat Mill	-	-	4,178.6	611.2	107.8		
Boilers (Process)	-	-	6,866	-	-		
General	-	-	-	107.3	-		
Total	130.8	18.5	13,221.5	4,005.3	184.9	248.1	
Total TCal	837.1	129.5	462.8	131.6	4.2	213.4	1,778.6
Percentage Share	47.1	7.3	26.0	7.4	.2	12.0	100.0

SOURCE : Reference (4)

B. Mining and Metallurgy

B.1 Branch Structure

Four enterprises comprise the branch : Southern Peru Copper Corporation (SPCC), Centromín Perú S.A., Minero Perú S.A. and Hierro Perú S.A. The former three process copper ore, except for Centromín Perú S.A., which also obtains zinc, lead, silver and 19 other products. Hierro Perú S.A. mines and processes iron ore.

B.2 Processes, Capacities and Output

Of the four enterprises mentioned, only Centromín Perú works underground mines. The enterprise works six mines and a metallurgical complex at La Oroya in the Central Andes. Southern's mineral is sent to the Ilo Smelter (Southern Coast) from its mines of Toquepala and Cuajone by rail. Blister copper is produced at Ilo, from where it is taken to the neighboring Minero Perú Refinery. Here, copper cathodes are produced by thermal and electrolytic refining. Minero Perú also produces copper cathodes from oxides, extracted from its Cerro Verde mines near Arequipa by an electrowinning process. Finally, Minero Perú refines zinc concentrates at Cajamarquilla, near Lima, through roasting, leaching, electrolysis and casting into bars. Table B-1 shows installed capacity and output by enterprise and product.

CAPACITY AND OUTPUT IN METALLURGY

Table B-1

Enterprise/Site	Capacity and Product (MT y)		Output and Year (MT)	
Southern Peru Copper Corp.				
- Ilo Smelter	300,000 Blister Cu	(99.2%)	240,807	(1982)
Centromín Perú S.A.				
- La Oroya	59,000 Cu Anodes	(98 %)	54,069	(1981)
	57,000 Cu Cathodes	(99.99%)	50,026	(1981)
	70,000 Zn Bars		72,487	(1981)
	92,000 Pb Bars		85,258	(1981)
Minero Perú S.A.				
- Ilo Refinery	150,000 Cu Cathodes	(99.99%)	141,630	(1980)
- Cerro Verde	33,000 Cu Cathodes	(99.99%)	33,366	(1981)
- Zinc Refinery	101,500 Zn Bars	(99.99%)	92,152	(1982)
Hierro Perú S.A.				
- San Nicolás Plant	7'600,000 Fe pellets	(65 %)	5'779,284	(1982)

SOURCE : References (6) and (7) ; Southern Peru and Hierro Perú

The percentage of capacity used is high, excepting Hierro Perú. Both the export and domestic demands for iron pellets have contracted considerably due to domestic and world recession and increased steel imports.

B.3 Total and Specific Energy Consumption. International Standards

Total mining and metallurgical energy consumption are shown in Table B-2. Of the total, given in TCal, between 70-73% was the fuel oil used in furnaces and boilers.

TOTAL ENERGY CONSUMPTION (in TCal)

Table B-2

ENTERPRISE	1980	1981	1982
Southern Peru Copper Corporation	3,795	3,589	3,822
Centromín Perú S.A.	1,019	1,069	976
Minero Perú S.A.	876	555	558
Hierro Perú S.A.	839	818	618
TOTAL	6,529	6,031	5,974

SOURCE : PetroPerú S.A. and General Directorate of Electricity.

The observed decline in total consumption is explained by the international recession.

Table B-3 shows the specific energy consumption, both thermal and electrical. These values can not be directly added, since all of the enterprises are self-producers of electricity.

SPECIFIC ENERGY CONSUMPTION (SEC)

Table B-3

Enterprise/Process	SEC Thermal (KCal/Kg)	SEC Electrical (KWh/TM)	Product and year
1. Southern Peru (Ilo)			
Concentrates to Blister	7,384 *	-	Blister Cu (1978)
2. Centromín Perú (La Oroya)			
Concentrates to Blister	7,000	n.a.	Blister Cu (1981)
Concentrates to Cathodes	8,780	n.a.	Cu Cathodes (1981)
Concentrates to Zn bars	385	4,000	Zn bars (1981)
Concentrates to Pb bars	4,820	180	Pb bars (1981)
3. Minero Perú			
Blister to cathodes	1,980	362	Cu cathodes (1980)
Concentrates to bars	283	4,212	Zn bars (1981)
Oxides to cathodes	10,350 *	3,800	Cu cathodes (1981)
4. Hierro Perú			
Mineral to pellets	225	-	Fe pellets (1978)

SOURCE : References (3) , (6) and (7)

* Includes fuel consumption for electricity generation. The SEC_{el} included refers only to electricity consumption.

Depending on the efficiency of electricity generation, a higher or lower specific energy consumption will be obtained. For example, the values shown for Southern and Cerro Verde reflect the different efficiencies of their respective generation systems, despite the use of different processes.

It is difficult to compare Peruvian with international standards due to the different ore grades and kinds of ore, of processes and electricity systems. It is estimated that to transform copper concentrates to blister in modern plants requires between 5,500 and 6,000 kCal/kg (Thermical) 1/, while some 6,500 - 7,500 kCal/kg (Th) and 200 kWh/MT 2/ would be needed for the process concentrates to cathodes. Hence, Peruvian values in copper are higher, in some cases substantially, than international standards 3/. Regarding peruvian specific consumption for producing iron pellets, it has been concluded that it is possible to lower this value by 20% 4/.

B.4 Share of Energy in Production Cost

Table B-4 shows energy shares as a percentage of total direct production costs; i.e. excluding taxes and interest. The high values obtained are partly explained by the cost of fuel for electricity generation; a particularly significant item for Cerro Verde, as was shown above. In contrast, the pellet plant at San Nicolás has used increasing amounts of cheap electricity by interconexion with the Mantaro hydro-plant.

SHARE OF ENERGY IN PRODUCTION COSTS

Table B-4

Enterprise	Share (%)
Southern Peru Copper Corporation	40
Centromín Perú S.A.	n.d.
Minero Perú S.A. : Refinado Cu	63
Minero Perú S.A. : Cerro Verde	83
Minero Perú S.A. : Refinado Zinc	69
Hierro Perú S.A.	25

SOURCE : Data given by the enterprises for 1982.

1/ Reference (7)

2/ References (7) and 15)

3/ References (3), (6) and (7)

4/ Reference (3)

B.5 Energy Saving Potential

Studies on energy conservation in Peru indicate that it is possible to save considerable amounts of energy with small to large investments. Improved operation of turbines and boilers has been recommended for Southern Peru, as well as the replacement of direct-fired air pre-heating for furnaces, by a system which recovers flue gas heat of the same furnaces, an improvement of the lime kiln and the use of converter waste-heat for steam raising. The latter can be considered a high investment option that could save 11% of total energy consumed. A further 14% saving would be possible after only small investments. (See reference (3)).

The case of Centromín Perú is very special due to the complexity (22 products) and age of the plant and equipment. An estimated 40% potential energy saving should, therefore, come as no surprise (Reference (3)). This does not include the savings achievable by substituting oxygen for air in the copper smelter.

Regarding Hierro Perú S.A., savings of about 20% have been estimated, mostly by improving the operation of the San Nicolás pellet plant. The enterprise has recently signed a contract with a local consultant for studying the increase in power factor from 0.84 to 0.91 and the reduction of losses in the enterprise's electricity distribution system.

Finally, the recommendations for Minero Perú S.A. and the measures taken are examined for each plant separately :

(a) Ilo Refinery : The integration of the operations of Southern's smelter with those of the Refinery and the balancing of the latter's thermal and electrolytical units would save about 15% of total consumption, after an investment of US$ 100 - 123,000 (Reference (6)). Regarding the balancing, Minero Perú S.A. has recently signed a contract with UNIDO for starting a pilot project of periodically reservable current in the electrolytic unit, allowing a greater effective capacity.

(b) Zinc Refinery : In general (Reference (6)) the recommendations are of marginal importance. Nevertheless, an inmediate saving of 2% would be attainable by investing only US$ 5 - 10,000. On the other hand, although the plant could operate continuously, a slower rate of production from 18:00 to 22 :00 hours is being considered as a way of reducing Lima's peak electricity demand. Moreover, steam raising by waste heat recovery from the roasting furnace is a possibility.

(c) Cerro Verde : The main problem is the high cost of electricity (US$ 0.12/ KWh versus US$ 0.08 at Southern's Ilo power plant, according to ref. (6) and Southern's data).

Hydro-power from Charcani V might not always be available, for Cerro Verde , because of the area's recurrent droughts. It would therefore seen advisable to transfer the firm's gas turbines to Arequipa where they would operate at greater efficiency due to the lower altitude and the possibility of cogeneration. At the same time, emergency diesel units, designed for fuel oil use, would be installed in Cerro Verde .

C. Cement

C.1 Branch Structure

The cement industry in Peru is composed of 5 firms, owning 6 plants sited throughout the country in the proximity of limestone quarries. Almost all of the output is Portland cement.

Currently the Government has a 49% share of the capital of Cementos Lima, Cementos Norte Pacasmayo and Cemento Andino and wholly owns Cementos Yura and Cementos Sur.

C.2 Processes, Capacity and Output

Two of the six plants use the wet process while the remaining four use the dry process. Capacity and output by plant for 1981 are shown in Table C-1.

C.3 Total and Specific Energy Consumption. International Standards.

Total energy for the branch was 2,667.8 TCal in 1981, as shown in Table C-1. The branch's 14% of total consumption in manufacturing makes ir the leading consumer in this sector. Almost all of this energy is used in the plants' rotary kilns.

Specific fuel consumption for the wet process was 1,370 KCal/Kg, compared with an average of 940 Kcal/kg for the dry process. The overall average value was 950 Kcal/kg (Thermal) and 15 KWh/kg, which is comparable to the specific consumptions in other countries, as shown below :

	Kcal/kg Cement	KWh/kg Cement
West Germany	800 - 1200	.118
Italy	900	.127
USA	886	.127
U.K.	1358	.163

SOURCE : Reference (10)

C.4 Share of Energy in Production Costs

The share of fuel oil fluctuates between 40 - 50%, according to the plant. The share of electricity is more variable, since some plants are self - producers while others draw electricity from the grid. Moreover, the primary source is sometimes hydro and sometimes fuel-oil. Therefore the share of electricity lies between 15 and 25% of costs.

C.5. Energy saving potential

The main studies carried out by the enterprises themselves on energy saving potential are :

Cemento Norte Pacasmayo :

- Energy Savings by aiding the grinding process.
- Clinker production with minimum energy expenditure.
- Portland Cement manufacture from slag.

Cemento Andino :

- Coal use in cement manufacture (in process).
- Energy saving in clinker production (in process).

Cemento Lima :

- Cement manufacture by puzzolana process.

In addition, the Ministry of Energy and Mines, within UNDP Project PER/78/010, prepared a survey of the whole branch (Reference (3)) and recommendations on energy saving in the two plants of Cemento Lima.

A study on the possible substitution of coal for fuel oil in this same enterprise has also been finished (Reference (14)).

In relation to the measures put into practice and the results obtained, we can mention the production of mixed cements, especially Portland and Puzzolana - type 1 PM cement. Also, since 1967 cement output is predominantly carried out by the dry process. The four main plants have installed pre-heating systems and some have pre-roasting or are planning to install such systems.

OUTPUT AND ENERGY CONSUMPTION IN CEMENT, 1981

Table C-1

PLANT	Process	Installed Capacity 10^3 MT	Cement Output 10^3 MT	ENERGY CONSUMPTION Heat (TCal)	Electricity (GWh)	SPECIFIC ENERGY CONS. KCal/kg (Th)	KWh/kg (el.)
Atocongo	Dry	1000	992.8	750.0	116.9	755.4	.12
Chilca	Wet	200	229.8	326.6	20.3	1412.1	.09
Pacasmayo	Dry	1000	404.0	383.9 (1)	79.6	950.2	.13
Andino	Dry	450	432.0	443.8	80.2	1027.3	.19
Yura	Dry	500	295.0	302.5	47.5	1025.4	.16
Sur	Wet	90	81.0	107.1	9.4	1322.2	.12
TOTAL	-	3240	2434.6	2313.9	353.9	950.4	.15

(1) Estimated.

SOURCE : References (11), (13) and (14)

D. Textiles

D.1 Branch Structure

Over 600 plants comprise the peruvian textile branch, the distribution of which, according to the Uniform International Industrial Classification (4 digits) is 1/.

UIIC		% Plants
3211	Spinning, weaving and textile finishing	41.8
3212	Textile Manufactures, except clothing	7.2
3213	Knitted - ware	45.3
3214	Carpeting	1.6
3215	Roping	2.1
3219	Other textiles	2.0

Clearly two sub-branches, numbers 3211 and 3213, account for over 87% of the firms.

D.2 Total and Specific Energy Consumption

Total energy consumption in textiles during 1979 was 960.2 TCal or 7% of total consumption in manufacturing (1.2% of Peruvian total).

The following table gives a break-down of energy consumption in textiles by sub-branch:

UIIC		Fuels %	Electr. %	Total %
3211	Spinning, weaving and textile finishing	91.1	87.8	90.1
3213	Knitted-ware	8.0	7.8	8.0
	Other sub-branches	0.9	4.4	1.9

1/ Reference (12)

It can be seen that the spinning, weaving and textile finishing sub-branch is by far the largest energy consumer. Moreover, only 5 plants account for 20% of the total fuel consumption. In this same sub-branch, the fuels were mostly used for steam raising, in order to carry out various processes, such as bleaching, mercerization, sanforization, dyeing, etc. On the other hand, the spinning and weaving operations use mostly electricity.

There exists a recently prepared energy audit of a Peruvian textile plant, (Reference (16)) which gives an average specific energy consumption of 14,860 KCal/kg of cotton cloth.

D.3 Share of Energy in Production Costs

This share has been put at 9.7% and 7.3% for electricity and fuels, respectively, in the case of Peru's largest textile concern, Fábrica de Tejidos La Unión Ltda.

D.4 Energy Savings Potential

In several of the textile enterprises various efforts at energy conservation have been made, although mostly partial and inmediate in nature.

The energy audit mentioned above (for the firm "La Parcela") has given the following recommendations :

- better boiler operation
- pre-heating of boiler feedwater
- improvement of insulation
- recycling of purge water

These measures would mean a saving of between 12 - 18% of total energy consumed, or US$ 25 - 38,000 annually. Further conservation measures, carried out through plant modernization, should allow additional energy savings of up to 10% in the short term and 20% in the medium term. The necessary investment would have paybacks of 1 to 3 years.

The firm "Fábrica de Tejidos La Unión S.A." has also put into practice several energy saving measures :

- installation of specially covered rollers in order to wring out an additional 35% of the water in textiles, thus saving 17% of the steam used for drying.

- changes in the system used for dyeing, at a saving of 4,082 KCal/Kg cloth.

- planning of production schedules and maintenance and insulation of steam distribution pipes.

The following measures were taken by the firm "El Amazonas" :

- increase in the power factor and coordination of production line start - up in order to reduce maximum load.

- improvement of condensate recovery system.

- study of a possible coal-fired steam turbine for process steam and electricity.

E. Sugar

E.1 Branch Structure

This industry is mostly established along the North Coast valleys and is comprised of a total of 12 cooperative plantations with sugar mills.

E.2 Processes, Capacity and Output

The sugar mills are composed of the following units : cane - crusher and press, difusor, evaporation pans, refinery and steam turbines. Table E-1 shows the output of crushed cane, bagasse and sugar of the 12 enterprises comprising the branch. Data on current installed capacity are lacking. However, in 1975 8.9 million MT of crushed cane were produced, which would indicate that the industry is operating substantially below capacity; in part because of drought and floods.

SUGAR OUTPUT BY ENTERPRISE - 1981

(Thousands of MT)

Table E-1

Enterprise	Crushed Cane	Bagasse	Sugar	Bagasse (in TCal)
Casa Grande	573.1	219.2	68.8	328.8
Cartavio	513.0	195.4	42.3	293.1
Paramonga	617.3	234.6	53.3	351.9
Tumán	761.2	271.7	74.1	407.6
Pucalá	830.4	283.1	90.3	424.6
Pomalca	684.2	219.4	63.5	329.1
Cayaltí	317.8	117.6	27.7	176.4
Laredo	258.4	81.0	24.9	121.5
San Jacinto	195.8	64.7	16.9	97.0
Andahuasi	205.6	65.8	21.1	98.7
Chucarapi	116.9	37.0	9.1	55.5
Ingenio	52.2	19.0	4.0	28.5
TOTAL	5'125.9	1'808.5	496.0	2,712

SOURCE : Reference (17)

E.3 Total and Specific Energy Consumption. International Standards

Table E-2 shows total consumption by fuel and enterprise. Electricity is not shown, since this is almost entirely self-produced; except for Paramonga, which was therefore treated specially.

TOTAL ENERGY CONSUMPTION OF SUGAR INDUSTRY 1981

Table E-2

FIRM	Diesel Oil (Th.Bbl)	Fuel Oil (Th.Bbl)	Bagasse (Th.MT)	TOTAL (TCal)
Casa Grande	25.6	329.4	180	790
Cartavio	21.2	258.8	162	652
Paramonga	12.3	325.4	195	787
Tumán	16.7	101.0	242	534
Pucalá	26.9	74.5	262	540
Pomalca	17.1	40.2	216	407
Cayaltí	9.3	51.8	100	239
Laredo	10.5	43.1	81	199
San Jacinto	6.3	-	62	102
Andahuasi	9.7	-	65	110
Chucarapi	5.0	14.7	37	84
Ingenio	3.5	-	17	30
TOTAL	164.1	1,238.9	1,619	4,474

SOURCE : Author's calculations, based on PETROPERU and Instituto del Azucar data.

Bagasse consumption has been calculated by using overall industry coefficients. Hence the specific consumption, 5,351 KCal/Kg, is an overall approximate average.

There is, however, a study of Paramonga referred to 1978, the results of which appear in Table E-3.

ENERGY CONSUMPTION IN PARAMONGA, 1978

Table E-3

Product	Specific Consumption KCal/Kg	Specific Consumption KWh/MT	Internat. Stand. (KCal/kg) Average	Internat. Stand. (KCal/kg) Modern
Raw Sugar	4,654	97	3000-3200	2000-2200
Refined Sugar	1,747	35	1500	1000-1300
TOTAL	6,401	132	4500-4700	3000-3500

SOURCE : Reference (3)

It is apparent that peruvian values are much higher than that of best international practice. This is because of inadequate maintenance of equipment, many of which date from 40 years ago. It has been calculated that, for example, many boilers are operating at low efficiencies : 65 and 70% for bagasse and fuel oil - fired boilers, respectively.

E.4 Share of Energy Costs

No data has been found for this calculation.

E.5 Energy Saving Potential

It is essential to install modern control equipment in the industry's boiler and ancillary equipment. It may be necessary to carry out a wholesale modernization of plant and equipment, given the age of that existing.

On the other hand, some cooperatives are studing the possibility of pre - drying the bagasse by using waste flue-gas heat from boilers.

A system of electricity generation based on coal has also been proposed ; one which would not only satisfy mill demand, but also that of nearby areas, traditionally subject to brown -outs and black-outs.

This option should be considered together with the sugar enterprises. Another similar problem is that of the paper industry, which uses bagasse as an input, purchasing it from the cooperatives at the heat-value equivalent price of fuel oil. Thus, the paper has a high and increasing cost, while the cooperatives must burn oil to fire their boilers.

F. Electricity Sector (Public Utilities)

F.1 Branch Structure, Capacity and Output

Peru's six electricity public utilities are : ELECTROPERU S.A., ELECTROLIMA S.A., HIDRANDINA S.A., SEAL, COSERELEC and EEPSA. These own 2,246 MW, or [illegible]4% of total installed generating capacity; and produce 75% of total electricity. The public utilities' capacity was 77% hydro and 23% thermal. The latter is comprised of steam turbines (44.5 MW), gas turbines (251.1 MW) and diesel engines (290.1 MW).

ELECTROPERU S.A. operates 287 power stations nationwide, totalling 1408 MW (75% hydro and 25% thermal) installed capacity and generating 4637 GWh in 1982. Only 13 plants are over 10 MW each in size, and jointly represent 90% of total capacity and 95% of output. ELECTROPERU S.A. serves about 33% of the population living within its concessions (372,000 clients).

ELECTROLIMA S.A. has an installed capacity of 599MW, including a 109 MW gas turbine, 41 MW other thermal and the remainder (75%) hydro. The enterprise serves Metropolitan Lima, a total of 682,000 users.

The area of influence of SEAL is the city of Arequipa (70,200 users), for whose service 70.8 MW are installed (57% hydro and 43% thermal).

F.2 Total and Specific Energy Consumption

The public utilities' fuel consumption in 1982 was 1986 TCal, including 1,238 diesel oil and 748 TCal fuel oil.

The yields in KWh per gallon of fuel are shown in the next page.

Type of Thermal Station	Yield KWh/Gal
Diesel	14.0
Steam	10.0
Gas Turbine	9.4

These values depend on the size, age, maintenance, and operating regime of the installed equipment. The yield value shown for diesel plants refers only to the larger, more efficient, units ; not to the vast majority of small units operated by ELECTROPERU S.A. whose yields are much lower.

F.3 Energy Saving Potential

Despite the lack of a formal program for energy conservation in electricity generation, several steps have been taken which tend towards a more rational use of energy.

ELECTROPERU S.A. has changed the merit order of the gas turbines of Chimbote and Trujillo from base or shoulder to peak or reserve, as a result of building the Lima - Chimbote transmission line. This line, by feeding the Chimbote - Trujillo system with hydro-generated electricity, will save a significant amount of diesel oil.

Looking south to Arequipa, SEAL has introduced the combined cycle in its system by installing a waste-heat boiler alongside its new 20 MW gas turbine. The extra 6 MW thus generated imply an increase in the efficiency of diesel oil use.

Turning now to ELECTROLIMA's rationalization activities, under the headings of combined cycle, modernization of street lighting and load administration, we observe the following possibilities :

- Extra generation of 40 MW by waste-heat boiler recovery at the 109 MW gas turbine.

- Replacement of 160,000 existing street lights by the more efficient mercury and sodium lamps, thus reducing total load by 22 - 24 MW and an energy of 98-100 GWh/yr.

- Direct control of maximum load by moving major industrial loads away from peak hours. The new tariff negotiated between ELECTROLIMA and MINEROPERU (see report in paper on Cajamarquilla Refinery), is a step in this direction. Indirect control would also be achieved by an intended marginal - cost pricing system.

IV. Policies for the Rational Use of Energy

The Peruvian Government has given a great importance to energy conservation. The Ministry of Energy and Mines Organic Law mandates the creation of a National Energy Council which has the function of regulating energy conservation. In step with this objective, a National Center of Conservation and Rational Use of Energy will be established.

This Center's activities include :

1. Increasing the overall energy efficiency of production and services. This includes extending the currently available "heat supplied" energy balances to the "useful-energy" level and the preparation of energy audits. Also included is a new legislation for promoting conservation on the part of final users by setting up the necessary regulations and incentives.

2. Coordinating the manufacture of energy-using equipment with conservation in mind.

3. Stimulating the substitution of oil products by other, nationally more desirable, sources of energy.

From the various studies and estimates available to the Ministry of Energy and Mines, it is thought that it is possible to save between 9 - 13% of the oil consumed in industry over the next 5 years ; and 25% over the next 10 - 12 years. Estimates for the short term indicate a possible saving of 1 million Bbl of oil per year, with a current value of about 30 million US$ per year.

For these results to take place, great reliance is being placed on the National Center of Conservation and Rational Energy Use. This Center must, therefore, be given adequate technical and financial resources, including those from international sources, the appropriate requests for which are now under way.

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UNITS

1 TCal = 10^9 KCal

1 GCal = 10^6 KCal

PRODUCT	LOWER HEAT VALUE
Coal (Anthracite)	7.00 Tcal/10^3 Ton
Firewood	3.60 Tcal/10^3 Ton
Bagasse	1.50 Tcal/10^3 Ton
Crude Oil	1.38 Tcal/10^3 Bbl
Associated Gas	0.234 Tcal/ 10^3 cu. ft.
Coke	6.40 Tcal/10^3 Ton
Charcoal	6.50 Tcal/10^3 Ton
LPG	0.95 Tcal/10^3 Bbl
Gasoline	1.22 Tcal/10^3 Bbl
Kerosene	1.33 Tcal/10^3 Bbl
Diesel Oil No. 2	1.38 Tcal/10^3 Bbl
Fuel Oil No. 6	1.48 Tcal/10^3 Bbl
Electricity	0.86 Tcal/GWh
Hydro-energy	1.075 Tcal/GWh

Rational Use of Energy and Oil-Substitution in the Textile Industry

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1. The position of the textile industry in The Netherlands and South America

The industrialised manufacture of textiles began in England in the 19th century. In the Netherlands textile mills arose in the middle of that century, being among the country's first major industrial enterprises. These wholly mechanised undertakings covered the whole range of the textile production process, including spinning, weaving, finishing and garment-making. In the inter-war years the Dutch textile industry flourished and exported much of its output, mainly to densely populated south-east Asia, in which Indonesia - then a Dutch colony - was a major outlet. World War II was turning a point. A number of concurrent factors contributed to a decimation of this once flourishing industry over a 20-year period. Main causes were:

- the emergence of production capacity in Asian countries like India, Taiwan and South Korea, which deprived the Netherlands textile industry of its main export market.
- low-cost production, in Asian countries in particular, flooded the Dutch home market with cheap imports.
- low efficiency of the Dutch production process in addition to high labour costs. As firms had to use a large part of their financial reserves to fund losses, they could not invest in new labour-saving equipment to replace obsolescent machinery. Table 1 shows this development in figures.

	1960	1970	1980
sales in million US$ (at current prices)	1,020	1,050	1,530
workforce x 1,000	116	60	32
% of total Dutch industrial output	7.6	8.0	2.3

Table I. Development of the Netherlands Textile Industry in figures (source: Netherlands Central Statistical Office).

Table II shows the development of Dutch manufacturing and trade in time, and the shares taken by some sectors.

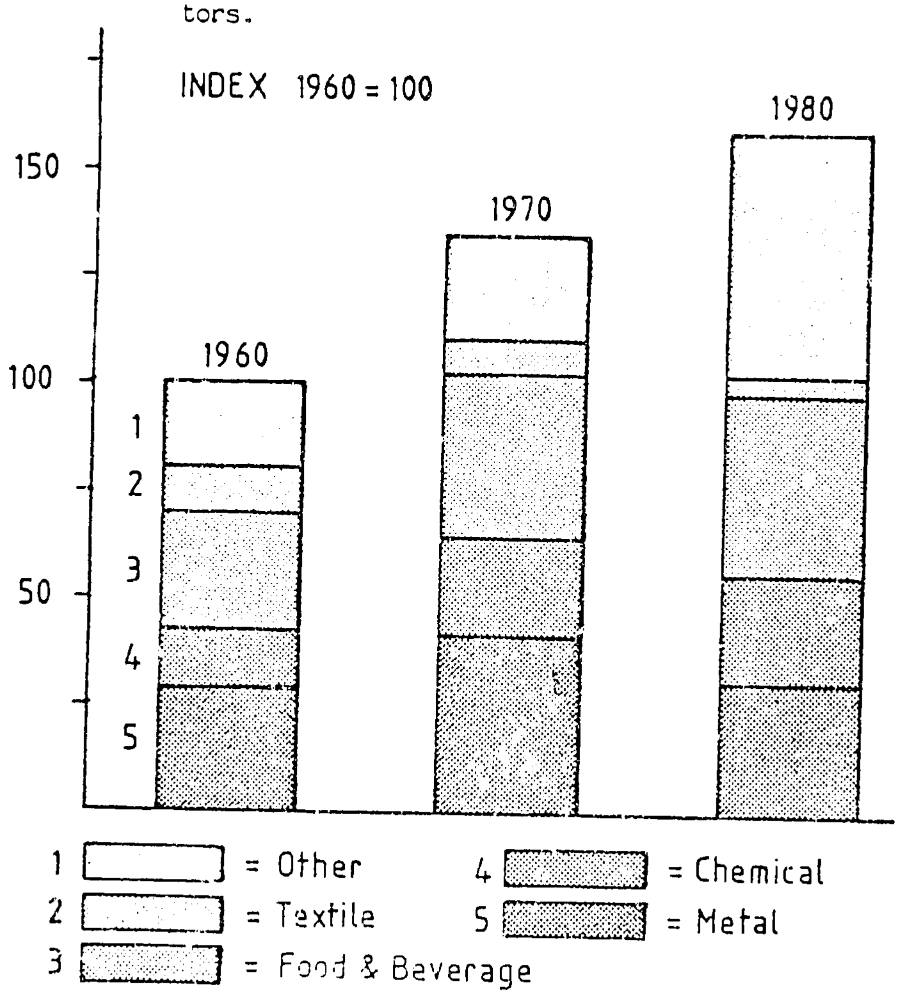

Table II: The development of the shares of various Dutch manufacturing branches in sales (base 1960 = 100).

Currently the Dutch textile industry is maintaining production at the same level through far-reaching specialisation.

The current production package consists of high-grade printed and treated fabrics for special uses, such as fashion clothing, recreational articles and the like.

As for South America, information available in the Netherlands - publications by the Netherlands Foreign Trade Agency of the Ministry of Economic Affairs - indicates that Brazil, Columbia and Argentina in particular have textile industries which are comparable with the Netherlands'. In those countries this industry has a substantial share in manufacturing output (Brazil 10% in 1980; Latin America totalling 8% in 1975).

2. Energy consumption in the Netherlands

The following chart affords a general, diagramatic insight into the actual Dutch energy economy.

42% industry	17% energy as raw material 25% energy-consumption
15% transport	
43% building area	

Chart I. The shares of the three major user sectors in Dutch energy consumption.

Table III surveys energy consumption by the various manufacturing sectors, making it clear that the textile industry has a relatively small share in total industrial energy consumption.

	percentage
Food, drinks & tobacco	7.6
Textile, garments & leatherware	1.4
Paper and printing industry	3.2
Chemicals, rubber-energy use	22.8
-non-energy use	42.7
Timber and building materials	4.2
Metallurgy	11.7
Engineering - electrotechnical	5.3
Other manufacturing	0.1
	100.0

Table III. Survey of energy use by industrial sectors in percentages.

3. Energy consumption in the textile industry

The information contained in this section and the next relates mainly to the most energy-intensive division of the textile industry, which is finishing. Finishing plants make all sorts of garment fabrics and soft furnishings and textiles used for recreational purposes. The materials that go into these fabrics are mainly cotton or cotton reinforced with polyester fibres.

Finishing serves to enhance the appearance and the performance of fabrics.

Processes to enhance appearance are in the main bleaching, dyeing and printing. The performance of fabrics can be enhanced by making them noncreasing, shrink-proof and water-repellent. All these treatments can take place during various stages of the production process - in the cotton-flock, yarn and tissue phases of the product.

As these treatments are carried out in various sequences, depending on the desired end product, it is impossible to describe a general textile finishing process.

At current Dutch energy prices, the share of energy in total production costs ranges between 10 and 20%. For current prices of fuels in the Netherlands, see Appendix 2.

4. Ways of cutting energy costs in the textile finishing industry

Energy costs in industry depend on:

- rates, which depend on external factors. Energy costs can be cut by switching to other, cheaper fuels. This point is discussed briefly in 4.2.
- the energy efficiency of production processes. The technical and economic aspects of energy-conservation in the textile finishing industry are discussed in 4.1.

Section 3 discussed the energy-intensive character of the textile finishing industry and the share of energy in production costs. An effective conservation programme can therefore bring a substantial improvement of the cost structure.

4.1 Rational energy use

Conservation measures can be taken in:
- production processes, as explained in Section 3.
- energy supply as regards steam generation in the central boilerhouse.
- heating of the plant and office buildings.

As explained in Section 3, the production process can best be described on account of four unit operations, mentioning the general measures for the various unit operations item by item:

- Mechanical pretreatments; points to be considered in singeing are: s
  a) higher transport speeds.
  b) adjusting the width of the burner section to the width of the cloth.

In these ways it is possible to attain a saving of 25-50% in comparison with unadjusted machines. Energy consumption per m^2 of fabric ranges between 0.03 and 0.19 MJ.

- wet pretreatments; the following points influence energy use during the strengthening of the yarns:
  a) the impregnating vat should be covered, with small openings left for the yarns to pass in and out.
  b) electricity supply to the drying cylinders should be cut off when the strengthening machine is idle.
  c) extra pressing of the yarns before drying.
  d) using the steam condensate leaving the drying cylinder to heat the impregnating agent.

The economic return on most of these measures is good (Table V).

	% steam saving	kind of measure	payback period
a	6	installing cover	6 months
b	3 - 5	automatic control devices	same
c	15 - 20	cannot be used with existing plant	2 years
d	3 - 5	piping system + tank	1/2 - 2 years

Table V Savings on strengthening of yarns. Energy use of strengthening machines ranges between 4.1 and 7.0 MJ/kg of yarn.

Another pretreatment takes place in so-called steamers (which are used also for fixing dyes and condensing synthetic resins on fabrics). In these months the cloth is brought into contact with air fully saturated with water-vapour at a temperature of 100°C.

To reduce energy consumption by these machines it should be tried to pass a larger quantity of fabric through the steamer and limit loss of steam through the exhaust system to a minimum.

Steam is exhausted at the openings where the cloth enters and leaves the steamer, so as to prevent cold outside air from entering (to this end a slight over-pressure is often maintained inside the steamer).

Depending on the steaming process used, energy consumption varies between 1 and c. 5MJ/kg of cloth. Exact conservation percentages are not known.

- Dyeing and printing; the main factors that can increase the energy consumption of dyeing machines unnecessarily are:

a) too large a ration between cloth weight and the volume of the dye bath. There are four kinds of dyeing machines (jiggers, reel vats, jet and overflow machines). An optimum ratio, based on practical experience, can be given for each machine type.

b) it should be endeavoured to keep the dye baths' temperature in open dyeing machines just under 100^{0}, so that steam supply can be controlled by thermostat. Moreover, a cover with a sight glass should be installed to prevent unnecessary heat losses.

c) in closed dyeing machines the water-vapour above the dyeing bath is sometimes exhausted. To avoid energy losses exhaustion had better take place after dyeing when heat supply to the bath has ceased.

By these means c. 50% of the energy consumption of the dyeing process can be saved without any investment (apart from the installation of covers on open dyeing baths).

Energy consumption can thus be reduced to 5-10MJ/kg of load, depending on the type of dyeing machine.

During printing a great deal of energy is required to evaporate volatile substances such as turpentine and water which are present in the printing ink or paste.

Most roller film printing machines dry the printed cloth with air heated directly by flames to 100-150^{0}C. Much energy is lost during drying by a too generous use of air for safety reasons in view of the turpentine vapour. Makers of printing machines can specify safety margins exactly. The critical explosion limit of an air-turpentine mixture is 0.6% turpentine by volume.

However, the following main processes are indispensable:

- mechanical pretreatments, such as singeing. This process consists of passing the fabric over flames via rollers. Scorching is prevented by cooling the burners, exhausting the combustion gases and moving the fabric along at a proper speed. This treatment serves to remove protruding fibres, so that a smooth surface is obtained.
- wet pretreatments, such as strengthening yarns and bleaching. To this end the fabrics are passed through chemical baths (acueous solutions), and then over steam-heated drying cylinders.
- dyeing and printing.
- after-treatments such as impregnating fabrics and fixation of the pigments on the cloth.

All these processes energy-intensive, because the baths of dyes and chemicals in aqueous solutions, which are constantly refreshed, have to be heated. After virtually all treatments the washed and pressed cloth is dried in various ways and/or brought into contact with hot air for fixing.

Apart from these thermal treatments, a great deal of mechanical energy is needed to move the fabric along over the rollers and to power the ventilators which carry off the saturated air after the drying process.

During a recent survey of ways of saving energy dn the Dutch textile-finishing industry, a number of key figures were fixed for energy use in a large number of plants involved in the survey. See reference survey in Appendix 1.

Table IV shows the chief energy consumption data for the Dutch textile finishing industry. They relate to the energy use, including heating, of the 16 Dutch finishing firms.

Total primary energy use in t.o.e.	gas	56,210
	oil	9,190
Do. electricity in kWh	public supply	$41.6 \cdot 10^6$
	own generation	$31.4 \cdot 10^6$
Average use per kg of fabric	primary energy in kg.o.e.	1.15
	electricity in kWh	1.0

Table IV. Energy use by the Dutch textile finishing industry. See Apendix 2 for energy conversion tables.

- after-treatments; these treatments consist mainly of drying the cloth and fixing pigments or synthetic resins.
  Cloth can be dried on a battery of cylinder dryers, the cylinders being steam-heated and used in most cases to dry the cloth between treatments. Major savings are possible through:

a) drying to a lower residual moisture content. This content can be influenced by varying steam pressure and cloth speed, without requiring any investment.
b) sealing steam leaks.
c) reducing standstill losses.

Standstill losses can be much reduced by a proper steam control device which need not be expensive. The payback period on US$1000 investment is only a few months.

Average energy consumption of cylinder dryers has been found to be between 3.0 and 4.5 MJ/kg of evaporated water.

Cloth can be dried in specially designed drying units in which it is stretched full width in a chamber into which hot air is blown. The saturated air is exhausted by ventilators. Fresh air is heated either directly by flames or by moving past pipes containing steam or hot thermal oil.

Energy consumption of these machines, including electricity use by the ventilators, is c.5-10 MJ/kg of evaporated water.

Energy can be saved by:

a) reducing the quantity of hot air, which can be done automatically by a control system monitoring the water-vapour content of the exhausted air and controlling air input. The rule should be a moisture content of 0.1 kg per kg of exhausted air. The investment in this device, which saves over 30% on energy, is not large and the payback period is less than one year.

b) drying to a higher residual moisture content; cotton cloth need not be dried further than to 6-7% residual moisture content in most cases.

Practical experience has shown that drying to 1% residual moisture content instead of 6 - 7%, causes an energy loss of 9%.

Energy can be saved also by extra pressing before the cloth enters the drying unit. If the moisture content is reduced by 5%, the energy saving is 4%. The two last-mentioned conservation methods do not require any investment.

By having the ventilators turn at the lowest possible speed c. 30% can be saved on power use in many cases.

Pigments and other organic substances are fixed in special ovens operating more or less by the afore-described process.

As in the drying process, energy savings are possible also in these ovens by a correct dosing of hot air. The air volume should not be larger than is needed to remove the released fixing substances with the exhaust air. Literature recommends 4-5 kg of air per kg of cloth.

On energy use ranging between 2 and 2.5 MJ/kg of cloth, including electricity use by ventilators, this measure resulted in savings of 25-50% in Dutch ovens.

Fuel consumption in the finishing industry does not only depend on the energy efficiency of production processes. Heating of the factory bays and the efficiency of the energy supply - boiler-house, combined heat and power plant - also play a role.

Ways of saving energy in these respects are not specific to the textile industry. In existing boiler houses, the following facilities are to be considered:

a. the use of an economizer, in which part of the heat contained in the combustion gases is transferred to the feedwater.

b. considerable energy savings can also be achieved by pre-heating the combustion air with heat recovered from the combustion gases.

c. in order to maintain water quality at the desired standard, boiler water is regularly discharged. The heat contained by this discharged water can be almost entirely utilized for the purpose of pre-heating the make-up water with the use of a heat exchanger.

d. the recycled condensate formed during the production process is usually collected in a tank at atmospheric pressure; as a result of this pressure drop which takes place, 10 to 15% of the condensate turns to steam; this is known as flash steam. In most cases this steam is discharged to the atmosphere, without considering the possibility of putting it to good use.

e. finally, two technical points about the boiler itself: make sure that the burner setting is regularly inspected to guarantee that it operates with the correct proportion of excess air. Also energy may be unnecessarily lost if the flue damper does not shut properly when the boiler is not operating. In Dutch firms it has been extablished that these combined measures are capable of yielding an average 7% saving on a factory's total energy consumption. All these investments have a pay-out time of less than two years.

4.2 Substitute fuels

The most-used fuel in the Netherlands is natural gas (see 3). Plants generating their own power, which is economically advantageous in view of the attractive heat-power ratio, use mainly gas engines or gas turbines. Fuel use depends on regional and economic conditions.

Technically speaking, the textile finishing industry can use every kind of fuel fit for burning in a boiler or a combined heat and power plant (coal, oil or gas). Using waste as fuel can be interesting. Possibilities are burning waste timber or other other organic wastes. With current combustion and gasification technologies waste can be used for energy generation efficiently and without undue environmental pollution.

Considering the constant demand of textile mills for steam and electricity, the wind and solar-energy options do not yet appear attractive, economically speaking, with the technologies now available.

4.3 Energy management

An industrial energy conservation programme cannot be launched and duly controlled unless there is an insight into the energy use of the various production processes in relation to output volumes. This means one should monitor energy use frequently by measuring enthalpy, kWh or steam at vital spots. Experience has shown that such a system does not function unless a directly responsible person is put in charge. This officer monitors consumption figures, compares them to the norms indicated in 4.1, and makes adjustments if needed. These figures will also serve as a basis for making correct decisions on investment in energy-saving equipment.

The following example from practice illustrates the importance of having an energy control system:

Investments in monitoring equipment (US$)	
- 6 steam gauge points	13,000
- 2 gas gauge points	1,450
- extra electricity meters	725
	15,175
Man-hours spent on energy management (hours per week)	
- energy coordinator	1 - 2
- manual processing of data	6
	7 - 8
total per year	400

Savings found as compared with previous years:

- fuel 23%
- electricity 7%

5. Introducing energy policies in manufacturing plants; roles of government and industry

Whether a specific energy programme can be carried out, depends in general on a number of factors which come roughly in the following four categories:

a) in-house knowledge of energy use in relation to output, technological and economic aspects of various conservation and fuel-substitution technologies.
b) the internal managerial system setting up and carrying out the energy control system.
c) a measure of certainty about future development of the undertaking is needed for investment decisions.
d) the financial position on the undertaking and its chances of borrowing for investment in energy-saving equipment.

Harmonisation and coordination of policies and activities of government, the undertaking and other parties as to the aspects mentioned under a-d above, can furnish the needed incentives.

Table VI below shows how these various aspects can be dealt with:

aspect	industry	government	others
a. knowledge	- active acquisition of knowledge, through government programmes etc - taking advice from consultancies, contractors & equipment makers.	- various forms of information programmes (possibly by sectors). - support and distribution of knowledge by demonstration projects - encouraging firms to apply for external advice (possibly through financial aid)	- consultancies - knowledge supply - exchange of knowledge (governments, firms, countries, international organisations) - contractors & equipment makers: supplying technology and knowledge.
b. management	- appointing & training responsible energy coordinator - management should include energy policies	- information	- response by consultances to demand - schools, organisation of energy-management courses
c. firms' prospects	- general company planning		
d. finance	- proper investment planning (making cost-benefit analyses).	- investment subsidies - guarantees - acting as an intermediary between banks and firms	- banks; granting loans for investment in energy conservation.

Table VI. Energy policies in industry.

Although energy prices are the chief incentive for firms to adopt energy policies, government can play a major stimulating role. It should aim in particular to make firms energy-minded. It can do so by granting financial incentives or promoting research and demonstration projects, and giving specific information based on such R&D activities.

Considering the homogeneous character of the industry, this had best be done sector-wise or through homogeneous unit operations.

It is important that firms introduce energy monitoring systems as a tool of management and acquaint themselves with energy technologies.

On the other hand, the consultancies, suppliers of equipment and banks will have to play an effective role in this market.

International cooperation, e.g., through exchanges of knowledge, can make a positive contribution to the entire process.

Appendix 1

The number and conclusions in this paper are based on an energy audit in the textile-finishing industry by:

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  Authors R.B.M. Holweg and H. Schukking
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  Netherlands, tel.033-17245
  Authors: J.A.H. Karsmakers and J. Boer

Appendix 2

The following conversation factors are used:

- 1 m^3 natural gas = 31.7 MJ
- 1 ton-oil-equivlanet (1 toc) = 40300 MJ
- 1 kWh = 3,6 MJ

The energy prices in the Netherlands are (1982)

- 1 m^3 natural gas = 0.16 US $
- 1 kWh = 0.07 US $

NATIONAL USE OF ENERGY IN THE TEXTILES INDUSTRY: "The Colombian Experience"

Hugo Serrano Marino
National Association of Industrialists of Colombia

1. Colombia was a petroleum exporter for several decades, but it began to import hydrocarbons at the beginning of the first oil crisis in 1973. It exported a high percentage of its reserves, while prices were low, and became an importer when they had begun to rise. This situation led to serious concern regarding the impact of these imports on the country's balance of foreign trade. Fortunately, the coffee boom, as well as the exportation of some petroleum derivatives and other items considerably reduced that impact.

Thanks to exploration work, the last few years have seen a reversal in crude oil production trends; and there is now hope that the country will soon become self-sufficient again.

2. Colombia could not be said to be facing an energy resource crisis, because it has appreciable coal reserves; an immense hydroelectric potential, of which only 5 per cent is being exploited; significant gas deposists; and very probably some radioactive minerals. Its geographical position also lends itself to the use of non-conventional energy sources, especially solar energy and biomass.

The critical resource is petroleum, and the search for more proceeds energetically, especially in promising new zones.

The country's energy problem arises, then, from the quite significant fact that the use of energy resource is in inverse relation to their availability. that is, consumption of the scarcest resource, petroleum, is the most common, whereas the most abundant resource satisfies a very minor part of all needs. Thence the importance of savings, rational use and substitution of energy. In some areas the substitution of liquid hydrocarbons by gas and coal is accelerating.

3. Aside from intensified oil exploration activities the country is currently engaged in two large projects, one of which has to do with large-scale coal extraction, especially to satisfy foreign needs, while the other hinges on hydroelectric development, the capacity of which should increase fivefold by the end of this century.

4. Energy policy has concentrated on activating petroleum exploration, on keeping prices in line with the tendencies of the world market, and on substituting coal and natural gas for some of the major sonsumption of liquid derivatives.

With the assistance of consultants from the Government of Germany, the country undertook the National Energy Study, the objective of which is summarized in the following words of the Minister of Mines and Energy: "...it will provide us with a mechanism through which we will be able to simulate different energy alternatives or scenarios along a time-scale extending to the year 2000. With its help we will be able to analyze the various segments having to do with the field of energy, determine and study the interactions among them all, gather the criteria necessary for decision-making, and suggest guidelines and goals aimed at achieving a rational use of our natural resources and an efficient allocation of our production factors."

5. With regard to industry, the National Energy Study reports the following: (1)

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(1) National Energy Study, pp. 110, 113, 224, 226.

Industry consumes over 30 percent of total energy and the average annual growth rate of consumption was 3.3 per cent between 1970 and 1979. However, in the case of petroleum, this rate was negative (-2.7%), in contrast with that of electricity, which was over 8 per cent per year. During the rest of this century, the share of industry is expected to increase.

The breakdown of energy demand in the industrial sector is forecasted as follows for the year 1990:

Electricity	18%
Coal	48%
ACPM	12%
Kerosene	2%
Fuel oil	9%
Natural gas	11%

The products whose consumption growth rate will increase are: electricity (8.5%), coal (6.3%), ACPM (5.2%), and natural gas (5.5%). The decrease is notable in Kerosene (-0.8%) and fuel oil (-0.2%). These growth rates will vary according to the context in which the economy and industry develop.

It is to be hoped that the process of substituting coal and electricity for petroleum derivates will continue.

"There is little to be said regarding energy conservation, as there is no adequate information on energy use and the efficiency of each product in each use. In aggregate caloric terms, without taking these efficiencies into consideration, energy demand grows at a yearly rate of 5.4 per cent, which is lower than the growth rate of industrial production, a fact which is reflected both in the conservation motivated by products' rising prices and in the change in the composition of the demand. For example, electricity, which is the most efficient product in most final uses, will increase its share in total energy from 13 per cent in 1980 to 18 per cent in 1990, and to 20 per cent in the 2000. Coal will go from 42 per cent in 1980 to 48 per cent in 1990, and to 49 per cent by 2000, and the rest of the energy will be supplied by petroleum derivatives and natural gas."(1)

This breakdown may vary according to pricing policies, especially those for petroleum derivatives. This policy is almost the only chance for conserving and substituting energy through general measures for industry. Speaking in terms of sectors, five account for 80 per cent of industrial energy consumption; these were studied by the ENE (petrochemicals, cement, foods and beverages, iron and steel, paper and pulp) and specific possibilities have been found, which should be stimulated through development credit(2).

6. The industrial sector is increasingly aware of the energy problem, not only as one notably affecting global economy, but very particularly one of special relevance to the firms themselves. Two forums that have been conducted regarding rational energy use in industry have contributed to this awareness, as well as the literature that production guilds have distributed on this topic*; the plans that each company has developed and that other firms have attemped to imitate; and the action of university

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(1) ENE, pp. 231

(2) ENE, pp. 656

* Manual for Electricity Savings in Industry" (ISA-ANDI) and "Energy Management in Industry" (Ministry of Energy of Spain).

centers acting both in the academic field (energy planning) and in business practice (energy balances and energy savings).

7. The foregoing context will enable us to comprehend the Colombian textile experience.

7.1 The textile sector has been one of the most heavily affected by the present economic crisis. In 1980 there were 500 establishments, which employed 72,000 people. Their output accounted for 10.2 per cent of the gross national industrial production; its share in the aggregate industrial worth was 11.3 per cent, and the sector's electric power consumption represented 13.4 per cent of the total consumption of all industry.

Chart No. 1 summarizes the comparative situation between the years 1974 and 1980 in the different sub-sectors. The figures for the present crisis are not yet known.

7.2 The National Energy Study has carried out several studies on specific sectors, including the textile sector, with the principal preliminary findings summarized below. This information is based on a survey of 16 representative companies from this sector[1].

Average energy consumption was 4.7 MWh/ton (electrical) and 1.49 TOE/ton (thermal). However, as Chart No. 2 shows, the results vary

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(1) Kirchenheim, Gerhard von; "Energy Consumption in Colombian Textile Industry". National Energy Study, Bogotá, D.E., November, 1982 (mimeographed).

greatly among groups of firms:

Three groups of firms can be seen: those of group 1, whose average indexes are similar to those of the firms that make up group 3, whereas the firms of group 2 cannot be compared at all, revealing poor conditions in their installations, or inefficiency in their use of disperse resources.

The portion of electricity in the sector's energy consumption is similar to that of other countries (25%). Coal and fuel oil have a very high participation, because the two largest firms generate their own electricity using coal, which is an abundant resource of that region.

7.3 In order to be able to evaluate the average consumption of the Colombian textile industry, the ENE used the American standards. According to these, average consumption should be 26.6 KWh/Kg, of which 21.5 per cent is electricity and 78.5 per cent is thermal energy. Consequently, Colombian industry is within the standards proposed for the United States in the energy efficiency improvement program.

The energy consumption of the firms studied appears in Charts Nos. 3 and 4.

7.4 The ENE has established that the energy conservation potential of the textile industry is very slight, since the temperature levels used in its processes are low. This potential totals 3.7 per cent of the total energy consumption. Of this sum, 29 per cent is related to recovery of residual energy, 38 per cent to equipment maintenance and replacement, 18 per cent to monitoring of auxiliary equipment, and 15 per cent to programming of operations.

Applying different growth rates to the per capita consumption of textile products and including energy conservation rates, the following evolution is expected for energy consumption factors in the coming years:

	TOE/ton	MWh/ton
1980	1.49	4.74
1985	1.47	4.67
1990	1.46	4.62
1995	1.45	4.58
2000	1.44	4.56

The potential savings calculated by the ENE is 8,140 TOE, for a textile production of 100,000 tons/year. This savings can be broken down as follows:

2,280 TOE from equipment replacement and modificaction
1,150 TOE from savings through administrative measures
1,140 TOE from savings in the boilers and auxiliary equipment
1,060 TOE from savings through heat recovered from the condensers
980 TOE from savings through heat recovered from steam
970 TOE from savings through optimization processes.

8. Taking the foregoing into account, a careful search was made of the experiences that the principal firms could offer in this field. After analyzing the data and examples presented, it seemed advisable to divide the information into two parts:

a) Projects already carried out.
b) Future projects.

8.1 Projects already carried out: These are not far-reaching projects, nor do they involve spectacular changes. So far small efforts have been made, with very good results.

Since they all involve simple things, it would not seem necessary to go into detail; only the investment costs and the annual savings are specified. This type of program has been developed in almost all the larger plants.

A - STEAM

1) Sheathing of Steam Piping (T)

Investment cost	US$ 304,570
Yearly savings	326,892
Recovery time	11 months

2) Water and steam loss in cord bleaching * (T)

Investment cost	US$ 950,356
Yearly savings	2,723,682
Recovery time	4.18 months

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* It was found that during 32 per cent of the working time of the bleaching-washing machines, they were not being used and they had the valves controlling water and steam flows open, because they were manually controlled. The process should be automated.

3) Water and heat recovery in a soda recovery machine (f).

Investment cost	US$	548,000
Yearly savings		1,200,000
Recovery time		5, 8 months

4) Hot water recovery (F)

a) Thread Dyeing Plant:

Investment	US$	160,000
Yearly savings		732,000
Recovery time		2.6 months

b) Cooling of compressors:

Investment	US$	160,000
Yearly savings		800,000
Recovery time		2.4 months

5) Change of steam turbines (F)

Investment	US$	2,400,000
Yearly savings		6,000,000
Recovery time		4.8 months

6) Installation of automatic valves (2 stages) (F)

Investment	US$	1,850,000
Yearly savings		2,800,000
Recovery time		7.9 months

7) Modification of the steam-reducing station (F)

Investment	US$	30,000
Yearly savings		2,000,000
Recovery time		0.18 months

8) Heat recovery in the bleaching zone (C)

Among the projects carried out in one of the textile companies, worth mentioning from the standpoint of energy savings in finishing plants, is the installation of heat recovery equipment for the bleaching zone.

The hot effluents are received at a rate of 1000 GPM, making them pass through a "Ludell" heat exchanger that transfers heat to clean water used in some of the machines involved in this same process. The savings in steam while using this equipment is some 8,000 pounds of steam per hour, produced using coal in the steam plant.

In the initial study that led to the realization of this project, it was decided to use the drainage from the machines that would produce the greatest heat, and that would be best located for an economical installation. Thus the following units were chosen:

Chamber No. 1 washer	-	170 GPM
Chamber No. 2 washer	-	130 GPM
Chamber No. 3 washer	-	380 GPM
Mercerizing washer	-	80 GPM
Seven J's washer	-	490 GPM

With a utilization factor close to 80 per cent, the continuous effluent of used water averaged out as 1000 GPM, with a temperature of 150° F.

It is thereby possible to transfer 9,000,000 Btu/hr. to some 360 GPM of clean water for consumption in the same bleaching machines. This means that to provide steam with a total heat of 1170 Btu/lb. and to pass water with 50 Btu/lb., approximately 8000 lbs/hr. would be required, which is the amount of the savings.

The cold clean water is generally at 82°F, and is heated to 132°F. Most water drain off has an average temperature of 150°F and leaves the exchanger at approximately 132°F.

Carrying over this same project to present conditions, the investment would be some US$ 100,000 (10,000,000 Colombian pesos). The savings in Colombian pesos per 8,000 lb/hr. would total 1760 pesos per hour of operation of this equipment. With a current estimated operation of 3800 hours per year, the total savings would be 6,88,000 pesos.

B - ELECTRICITY

In this field the following statistics stand out:

1) Rationing of lighting on holidays and normal days (F)

Investment	US$	180,000
Yearly savings		6,500,000
Recovery time		0,33 months

2) Lowering lighting levels in offices and service zones (F)

Investment	US$	120,000
Yearly savings		1,000,000
Recovery time		1.4 months

3) Modification of lighting in the tire lashing and weaving area (E)

The project consisted in reducing the height of the lamps and changing them from 4 fluorescent tubes to 2, thus increasing the illumination factor from 70 to 90 per cent and facilitating lighting repairs and maintenance operations.

Investments	US$	806,000
Yearly savings		532,075
Recovery time		18.2 months

The manpower required for maintenance was also reduced, as was the changing of replacement parts, through the elimination of a significant number of flourescent tubes, ballasta, and bases.

C - AIR

Just changing the valves in the cleaning zones to 1/4" allowed one compressor to be turned off. (F)

Investment	US$	100,000
Yearly savings		2,000,000
Recovery time		0.6 months

D - FUEL

1) By centralizing steam services and installing an additional network, it was possible to eliminate boilers that consumed 380,000 gallons of fuel oil. (F)

Investment	US$	5,000,000
Yearly savings		9,900,000
Recovery time		6.1 months

As a final note regarding the projects that companies have already carried out, the following summary of all such projects to date may prove worthwhile: (F)

Grand total of investment	US$ 12,815,000
Grand total of savings	45,352,000
Recovery time	3.4 months

8.2 Future Projects: Business is fully aware that energy savings hold vast possibilities for future action and also that the really important projects have yet to be carried out. It would therefore seem useful to outline some of the main projects that are being considered, the implementation of which will depend on companies' economic situation and the support lent by the Government to this type of program.

a) Hot air recovery in output ventilators of finishing plant machinery (F):

Investment	US$ 16,500,000
Yearly savings	10,300,000
Recovery time	12.3 months

b) Heat recovery in Baghouse stack (F)

c) Replacement of a 1-stage soda recuperator by a 3-stage one (C)

Investment	US$ 8,000,000
Yearly savings	7,800,000
Recovery time	12.3 months

d) Substitution of boilers, to substitute coal for liquid fuel (C)

Investments	US$ 60,000,000
Yearly savings	50,000,000
Recovery time	14.4 months

e) Reduction in coal consumption, improving the efficiency of the thermoelectric plant, by means of the application of electronic instruments to control the airflow, the coal input, the fuel oil flow, the total calories, the dome level, the water flow, the furnace pressure, and the distribution of the load and fuels. With this system, coal consumption can be reduced by 5 per cent without varying the steam and electricity outputs. (C)

Investment	US$ 32,000,000
Yearly savings	13,600,000
Recovery time	28 months

f) The new plants are being outfitted with HID (Halide metal) lighting systema. This change is based on the fact that flourescent lamps cost 39.8 per cent more during the first year of operation.

For an open-end spinning room with a 60 fc level, an area of 15000 square meters and a height of 4.5 meters, this change should yield the following results (C):

Flourescent Lamps (2 X 40w)	US$ 10,688,230
Halide Metal - Direct 400w	7,642,124

g) Another field of action in the area of electricity is the substitution of conventional motors by high-efficiency engines. The largest investment that this would imply, in the case of changing a 20 HP-480V motor, would be recovered in approximately 8.5 months. (C)

h) These companies have, among others, studies completed or underway regarding:

- Heat recovery from effluent waters in various processes (C)
- Application of temperature regulators in various finishing processes (C).

CONCLUSIONS

a) The Colombian textiles industry is operating within the energy consumption standards.

b) Some projects have been under development that will allow energy resource savings and easy recovery of investments.

c) Studies are ready to undertake more grassroots actions in energy savings and conservation. Their completion will depend on the availability of companies' economic resources and the stimuli granted by the Government to this end.

Table 1

DISTRIBUTION PRODUCT-QUANTITIES & PERCENTAGE OF ENERGY CONSUMPTION BY THE STATISTICALLY REGISTERED SUBSECTORS OF THE TEXTILE INDUSTRY
(GROUP 321)

		1974 Enterprises	1974 Production t/a	1974 Weight % of all textiles	1974 % of Textiles Energy Consumption	1980 Enterprises	1980 Production t/a	1980 Weight % of all textiles	1980 % of Textiles Energy Consumption
321-1	Yarn & Woven Finished Fabrics	99	46,897	36.3	29.8	133	88,639	61	57.8
321-2	Manufactured Textile articles (except clothing)	29	590	0.45	0.3	45	948	0.65	0.5
321-3	Production of Knitwear	143	1,306	8	4.6	172	19,196	13.2	8.8
321-4	Carpets & Tapistry Production	29	403	0.3	0.3	29	556	0.3	0.4
721-5	Cordage Production	9	980	0.76	0.3	5	1,277	0.88	0.4
721-6	Production of cotton & cotton mixed textiles	33	57,246	44	53.7	36	21,790	15	21
321-7	Production of wool & woollen mixed textiles	38	3,033	2.3	3.3	18	2,500	1.7	2.8
321-8	Production of fabrics by synthetic, artificial & mixed textiles	44	9,260	7.1	7.4	47	9,284	6.3	7.5
321-9	Production of other textiles N.E.S.	8	407	0.3	0.3	15	908	0.79	0.7
321-1	TOTAL	432	129,122	100	100	500	145,062	100	100

TABLE 2

ENERGY CONSUMPTION OF DIFFERENTLY STRUCTURED TEXTILE PLANTS IN THE TEXTILE INDUSTRY OF COLOMBIA

	Enterprises	Input To/Year	% of Colombia Textiles In - dustry		Energy Consumption		Specific Energy Consumption	
			Statistic evaluation	Assumed projection	Electric Consumpt. Mwh/year	Thermic energy Tcal	Mwh/to (electric)	TEP/to (thermic)
Main types of common textiles	A/B/C/D/E/F	46160	51	32	175835	500.36	3.8	1.34
High quality Fabrics	H	15492	17.1	11	118278	472	7.6	3.0
	J	7488	8.3	5	32060	96.2	4.3	1.28
All types of Light textiles	G/K/L/M/N/P/Q	8647	9.6	6	42853	91.44	4.6	1.05
TOTAL AVERAGE		77787	86.0	54	369030	1160	4.7	1.49

FUENTE : Estudio Nacional de Energía; Energy Consumption

TABLE 3

EVALUATED ENERGY CONSUMPTION OF TYPICAL SUBSECTORS IN THE TEXTILE INDUSTRY

	Code	Input/Output To/Year	Consumed Electricity Mwh / Year	Consumed Thermal Energy Tcal/Year	Specific Energy Consumption MWH/To	Specific Energy Consumption TEP/To	% of Total Textiles Production Evaluated	% of Total Textiles Assumed	Fuel Consumption Coal t/a	Fuel Consumption LPG t/a	Fuel Consumption Fuel Oil t/a
Integrated Textile Company	A/B/C D/E/F	46.260	175.835	500.36	3.8	1.34	51	32	18980	56.5	37.638
Large Producers of Fabr.	H/3	22.980	150.342	568.2	6.5	2.4	25.4	16	87280	242	3.480
Medium Sized Producers of High Quality Fabrics	K/L	2.115	15.948	23.4*	7.5	1.1	2.7	1.4	1800	94.4	2.320
Yarns Producer (Spinning)	G	984	4.380	–	4.4	–	–	–	–	–	–
Knit – wear Producer	P/Q	2.788	11.605	24.9	4.1	1.12	3.6	1.9	–	–	2.534
All textile Operations (except Knitting	M/N	2.760	10.920	43.14	3.9	1.56	3.5	1.9	–	90.8	4.252
Finishing (dyeing, Washing thermofixing)	E/R	5.156**	5.759**	55.55**	1.11	1.00	–	–	–		
TOTAL		77.787**	369.030	1160	4.74	1.49	86.2***	53.2****	108060	483.7	50.224

L "Without finishing"

** Without input of finishers and their energy consumption, which is included in the energy consumption of the forementioned enterprises

*** Based on Dane data annual production by weight

**** Based on Dane date annual consumption of electricity

Source: Estudio Nacional de Energía.

TABLE 4

EVALUATED TOTAL ENERGY CONSUMPTION (KWH/KG) IN THE COLOMBIAN TEXTILE MILL-INDUSTRY *

Code		KWH/Kg	Code		KWH/Kg
A	Mixed Cotton-Syntheties Spinning, Weaving	12.5	J	Mixed Cotton, Spinning Weaving Finishing	19.2
B	Knitting Finishing	24.7	K	Spinning, Weaving, Dyeing, Finishing	26.9
C	"Open-end Spinning"	7.4	L	Wool-Washing, Woolen & Mixed Woolen Fabrics	11.2
D	Cord & Velvet Spinning	23.3	M	Weaving, Knitting Dyeing, Printing, Treating	27.7
E	Textiles Finishing	22.3	N	Spinning, Weaving, Knitting, Dyeing Printing, Rubberizing	14.7
F	Carpets & Rugs	22.2	P	Texturizing, Raschel-Jacquard-Circular Knitting	14.0
G	Spinning Texturizing	4.4	Q	Texturizing Circular & Warp-Knitting	15.4
H	Spinning Weaving Felting, Dyeing Finishing	42.5	R	Textile Finishing, Dyeing, Washing Thermofixing	10.7

* Conversion rate : 860 Kcal = 3.412 Btu = 1 KWH.

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RATIONAL USE OF ENERGY IN TRANSMISSION AND DISTRIBUTION OF ELECTRICITY: "The Experience of Costa Rica"

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1. INTRODUCTION

The rational use of energy in the generation, transmission and distribution of electricity should be framed within the economic and financial context of the country, its sources of energy, and its energy requirements. Therefore, the present paper will touch upon different topics that can contribute to forming broad criteria as to scopes and limitations.

As a complement, the policies adopted, the work undertaken and the results obtained in the Costa Rican system of electricity transmission and distribution will be commented on.

For many years, the efficiency of the power system was invariable and went practically unperceived. It was as the energy crisis unleashed in 1973 sharpened, that a need arose to reduce losses, since the energy independence of any country is closely tied to its energy conservation policies. Nevertheless, the balance between capital investments and energy losses continues to depend on the financial situation of the electric power companies; on the philosophy of operation, development and integration in the electric power industry; and of course, on the policies dictated by the national planning and regulation entities.

All of a country's power systems involve four basic areas: generation, transmission, distribution and utilization of energy. In each one ot these areas, losses occur. This paper concentrates on those corresponding to energy transportation and distribution. It is worthwhile to note, however, that the extreme stages, of generation and utilization, occasion appreciable losses which should also be investigated.

The transmission system losses can be controlled both in the planning stage as well as during operation, since the voltage levels and the way in which active and reactive power is dispatched allow for control over the magnitude of such losses.

The distribution system is more rigid because, since it is basically radial, the losses depend exclusively on the voltage utilized and on the circuit load density.

Planning of the power system, by controlling the development of the same according to anticipated market evolution, on the basis of forecasts for its future behavior, proves to be a fundamental tool in assuring rational use of energy as well as funding within reach of the companies, given that it opportunely defines future expansions and additions that the systems will be requiring, in keeping with the configuration projected for them individually and as a whole.

Usually, the degree of coordination among the electric power companies of a country, in the fields of planning, development and operation, greatly incluences the rational use of financial resources and energy resources in the systems under their responsability, whose development and operation should be handled jointly in the search for optimal results.

2. THE COUNTRY'S ENERGY SOURCES AND REQUIREMENTS AND THE ELECTRIC POWER INDUSTRY

a. Geographical Features

Costa Rica is a small country, with almost three million inhabitants and an area of 51,000 km^2, occupying 9.4% of the Central American territory. It is basically an isthmus of 240 kms. wide, crossed by an axis of mountains, overwhelmingly volcanic in the northwest and older, steeper and higher in the southeast. The Central Valley is located at the point where the two sectors join, and this valley is the site of the major settlements.

In most of the Costa Rican territory, the rainfall fluctuates between 3 and 4 meters of annual precipitation. The climate is therefore tropical rainy, although certain regional variations occur depending on influences from altitude and winds.

The eastern sector of the central valley drains through the hydrographic system of the Reventazon, whose waters are used to generate a large part of the country's electricity. The western sector drains through the Virilla and Grande de San Ramon Rivers, which also contribute to electric power generation.

In the north, the natural lake of Arenal has become the most voluminous reservoir of the country; its waters are utilized both for hydroelectric generation as well as for irrigation in a vast territory characterized by prolonged, arid summers.

In the south, the Boruca project has made the Rio Grande de Terraba the foremost source of hydroelectric generation in the country.

It is evident that its geographical conditions guarantee for Costa Rica an invaluable hydro power potential, which, in a world needy in terms of energy, constitutes an important resource for development.

b. Total energy consumption and consumption by sectors

The country's total energy consumption in 1981 (1) showed strong external dependency by the consumption sector, since nearly 49% corresponded to hydrocarbons, which had to be imported. Firewood and vegetable residues accounted for almost 40% and electricity for the remaining 11% of the country's total energy consumption. Currently, electricity is 99% hydro-based.

(1) 1980 Annual Statistics, Ministry of Energy

For conventional sources, this consumption can be divided into 70% commercial energy and 30% non-commercial.

As for consumption by sectors, "commercial" energy has the following breakdown:

Transportation	45%
Industry and Agriculture	36%
Residential and Commercial	15%
Others	4%
Total	100%

Energy consumption structure by subsectors is as follows:

	Oil Derivatives %	Electricity %	Charcoal, Firewood & Vegetable Residues %
Transportation	99.2	0.2	---
Industry/Agriculture	47.5	15.3	37.2
Residential/Commercial	6.8	18.4	74.8

In absolute values, we have the following total energy consumption, in terajoules, by sector and by type of energy:

COSTA RICA: NET ENERGY CONSUMPTION BY SECTOR AND TYPE OF ENERGY

Year 1980
(Terajoules)

	Residential/ Commercial	Transportation	Industrial/ Agricultural	Others	Total
Electricity	4 367	29	2 520	156	7 072
Liquified gas	913		105	71	1 087
Gasoline		5 803		8	5 811
Kerosene & Jet fuel	699	938	176		1 813
Diesel oil		12 435	1 633	105	14 173
Fuel oil			5 433	983	6 422
Non-energy				594	594
Firewood	373				373
Coal			12		12
Firewood	17 400		679		18 079
Veg. residues			5 288		5 288
TOTALS	23 752	19 205	15 852	1 917	60 726
% of Total Energy Consumption	39.1	31.6	26.1	3.2	100
Commercial Energy (70.2%)					42 647
Non-commercial Energy (29.8%)					18 079

c. <u>The country and its energy resources</u>

- The hydroelectric resources currently constitutes the country's main source of energy available and sufficiently developed and quantified.[(2)] Seventy-five projects have been identified (larger than 40 MW), totalling a theoretically exploitable potential of some 37,000 GWh/year, with an installable power capacity of some 9,000 MW, with an average plant factor of 0.5. (See figure 1). Currently, only 614% of the identified hydro-power potential has been tapped.

(2) Ministry of Energy and Mines, Costa Rican Institute of Electriciry and United Nations "Energy Development Alternatives". January 1981.

- Another abundant form of energy existing in the country -and like the preceding form, renewable as well- is biomass in general, and firewood in particular. The area covered by dense forests and medium-dense forests represents around 46% of the national territory.

Considering first of all firewood utilization at the commercial level, as a product tied to forestry exploitation, it is estimated that a volume something over 100 million m^3 of firewood could be obtained from the producing forests, with an average 5 million tons of firewood per year.

- As for vegetable residues, sugar cane bagasse and coffee husks are both currently used in their entirety. The manual production is between 700,000 and 800,000 tons of bagasse and some 22,000 tons of coffee husks, based on annual sugar cane and coffee production, respectively.

- With respect to alcohol, as obtained from different plants and even from wood, it is estimated that there is enough land to yield some 400 thousand m^3 of alcohol for fuel purposes, annually.

- As for geothermal energy, to date 54 places of interest have been identified, but only the Miravalles Geothermal Project is in an advanced stage of development, with three wells drilled so far, wherein a potential of 78 MW has been verified. This could funcion for a 20-year period, with a high plant factor. It is anticipated that the first 55-MW unit could be put onstream by 1988.

- With regard to fossil fuels (hydrocarbons and coal), there is evidence that these could exist, although reserves have not been quantified. In both cases, programs are underway, geared to completing the investigations necessary for the due assesment of these resources.

- With relation to non-conventional sources of energy such as wind and solar, insufficient basic data are currently available for the quantification of resources with a certain amount of "educated guessing". Some preliminary evaluations indicate five areas with greater possibilities for tapping the winds of the country; whereas in terms of solar energy, the best conditions appear in the dry Pacific and Central Valley areas.

d. Organization of the energy sector

The country has two State agencies to execute national energy policies: the Costa Rican Institute of Electricity (ICE), in charge of generating, transmitting and distributing (in part) electricity throughout the national territory; and the Costa Rican Petroleum Refinery (RECOPE), in charge of importing, refining and distributing oil and oil derivatives. The former is an autonomous State institution and the latter operates as an independent company whose stocks are in the hands of the State.

Both entities are responsible for evaluating similar resources, hydroelectric and geothermal in the case of the ICE, and oil and coal in the case of RECOPE.

Energy research work is in progress at the two State universities and at the Technological Institute of Costa Rica (also a State enterprice), which fundamentally seek the utilization of non-conventional energy (solar and biomass, etc.) on a small scale for use by households or small agro-industry.

In addition, there is a ministry in charge of directing energy policy, i.e., the Ministry of Industries, Energy and Mines (MIEM), which, through a Sector Division, is responsible for compiling statistics on energy consumption and for coordinating the sector. With this aim in mind, a National Program of Energy Planning and Development has been prepared and is being implemented, with funding and aid from several international institutions.

e. The electric power subsector: its characteristics and organization

The electric power subsector is composed of the ICE, previously described, and two municipal companies which generate and distribute their own production, as well as that acquired from the ICE; three rural distribution cooperatives and a company originally privatly owned with foreign capital (National Light and Power Company: CNFL), 92.3% of which now belongs to the ICE and which is in charge of distributing in the Metropolitan Area, mainly using its own energy and that acquired from the ICE. The National Interconnected System (SNI) links all of the main plants with consumption centers throughout the national territory, serving 98% of the country's total consumers. The remaining 2% are served through small isolated plants, which are mostly thermoelectric. Currently, 73% of the country's population has electricity services. The Second Stage of the National Plan of Rural Electrification is being carried out; this will make it possible to extend electrical services to settlements progressively more removed from urban centers. These rural services are being installed according to social criteria; and they are subsidized by urban consumers, within a State policy to improve the standard of living of the peasant populations, thus avoiding their migration to the cities. Figure 2 shows the area served by the different companies in Costa Rica. There is a regulating organization for electric power power service, known as the National Electricity Service, whose functions are, among others, to review and approve electric power tariffs or rates for all of the country's public enterprises and to monitor the quality of electric power services. In general, an attempt is made thereby to keep the residential consumer tariffs, in the first block (up to 300 kWh), at lower per-kWh values, thus subsidizing them from larger consumers whose economic capacity is greater. Likewise, the tariffs structure tends to decrease the wasteful use of electricity, discouraging greater use with ever higher tariffs.

f. Preponderance of hydroelectric generation

The law which established the ICE, in the year 1949, obliges it to resolve the problems of electricity supplies, with emphasis on the development of the hydro power reserves possessed by the country. However, before the world energy crisis of 1973-74, the most economical kWh was obtained with a thermal component of nearly 30%, generated in diesel-type units which used Bunker C for fuel.

The uncertainty observed as of that time, in terms of the cost and supply of oil derivative fuels, obliged the ICE planning sector to spur the utilization of the hydroelectric resources, eliminating the use of thermoelectricity. For this purpose, it was recommended that previously existing hydro power plants be enlarged and that the construction of the Arenal hydro power station be speeded up, in order to contribute its pluri-annual flow regulation to the system. The actions would make it possible to attain a 100% hydro generation for the Interconnected System as of 1980. It only remains to eliminate a few isolated centers which will be integrated into the SNI over the next few years; then the electricity generation of the whole country will be totally free of its dependence on imported fuels.

Aside from the enormous economic advantage of not depending on imported hydrocarbons for this subsector, the predominance of hydroelectric plants over thermoelectric ones (which have come to work basically as reserves) in hydrologically-favourable years (with figures higher than those for the critical values) entails a hydroenergy surplus which can be exported to neighboring countries.

g. Unified planning and coordinated development for the electric power subsector

Planning of both the system of generation as well as the system of transmission is carried on by the ICE, considering the country as a whole, i.e., taking into account the needs of each geographical region and the electric power companies existing in the country.

In order to define the start-up date of the generating plants, one must part from the market for electricity, combining all future comsumption of the different regions and companies throughout the national territory which are integrated into the SNI or which will be joined to this system within the planning time horizon (usually 15 years).

The foregoing leads us to consider, too, integrated planning for transmission and distribution grids, independently of the segregation of the area served by each company.

As a short-range objective, an attempt is being made to unify the tariff levels so that there will be uniform tariffs throughout the country, no matter which company is the distributor.

3. THE SYSTEM OF GENERATION

In order to provide a frame of reference for the main topic herein, and due to the major influence exercised by the location of generating sources for the transmission system, it is useful to explain briefly the aspects related to the system of generation in Costa Rica, without dealing with the topics of the presentation relative to energy economics in generation, since these lie outside the objectives of the present paper.

a. Selection criteria

From the list of 75 projects of 40 MW or more, which have been defined in the process of inventorying the hydroelectric resources of the country, the most suitable ones are being chosen from the stadpoint of energy costs and energy features in order to meet, as economically as possible, the needs of the electricity market. From these, the next one to be constructed must be selected, using the concept of the lowest-cost alternative (investment, operation and maintenance) by means of an analysis of present value. Figure 2 shows the current development program for the National Interconnected System.

b. Composition of the National Interconnected System and Isolated Centers

The generating plants of Costa Rica are mostly joined in the National Interconnected System (SNI), which serves 98% of the country's consumers. The transmission system of 138 and 230 KV serves the economically more active areas of the country; and the 34.5-KV distribution lines cover a good deal of the rest of the country, except for the areas still served by 13.2-KV lines. In the south of the country, there are isolated thermoelectric stations with greater capacity: Ciudad Neily, with 7,000 kW and Palmar, with 3,300 kW. Other isolated centers are: Los Chiles, with 450 kW; Upala, with 735 kW; Puerto Jimenez, with 525 kW; Nosara, with 750 kW; and Cahuita, with 450 kW.

The isolated centers of the southern area will be integrated into the SNI during 1984, as part of the extension of the interconnected 230-KV lines which in that same year will reach as far as the border with Panama. Other plants that will be integrated during 1983 and 1984 are: Cahuita, Upala, Guatoso and Nosara, through the extension of the 34.5-KV distribution lines. With the aforementioned work, the electricity generation of Costa Rica, which is currently 99% hydro-based, will practially hit 100% hydroelectric production as of 1984.

c. Areas under research and development

As explained previously, the development of the electric power sub sector in Costa Rica has been based on the increased hydroelectric gen erating capacity. The elimination of thermoelectric generation has be en accomplished thanks to the development of Arenal-Corobici hydro pow er complex with a 330-MW capacity, and an average annual generation of 1500 GWh. In order to avoid the burning of imported fuels in the future, the development of the Miravalles geothermal field is being sounded out. Its technical and economic feasibility is being determin ed, and there are plans to install a first 55-MW unit by 1987 and a second, of equal capacity, by 1991.

The Costa Rican Petroleum Refinery (RECOPE) is parallelly carrying out oil explorations and investigations of the country's coal potential. It is known that there are coal deposits in different places within Costa Rica, but no detailed assessment of this resource has ever been undertaken. Should the existence of this resource be shown in suitable quantities and qualities, the possibility of installing a coal-based thermoelectric plant could also come to be considered, as a complement to the run-of-the-river hydro plants which might be built in the future.

4. THE SYSTEM OF TRANSPORTATION

For Costa Rica, which is characterized by being one of the few countries still capable of self-sufficiency in terms of hydroelectric generation, the energy transportation system holds special importance, since it is the only means at their disposal for carrying energy from the hydro power stations to the consumers dispersed throughout the national territory.

Through this system, the Costa Ricans have an energy alternative that permits them to maximize the reduction of imported fuel consumption.

It has been necessary, therefore, to guarantee the optimal utilization of the installations and to minimize losses in transportation, through the continuous monitoring of the behavior of the system and of the electric power markets.

It is planned with broad prospects for the future, and periodical adjustments are made in order to maintain suitable agreement between the development of the work contemplated in the plans and the real needs of the moment.

An attempt is thus made to take the necessary corrective measures to optimize the energy supply, in keeping with the apprearance of new loads and modifying, where necessary, the plans and/or the capacity for transportation in future lines.

The programs to reinforce and expand the installations, the work relative to reconstruction and important changes, and the corresponding investment programs on the whole obey overall planning that maintains the necessary parallelism among generation, transmission and distribution projects.

In this way it has been possible to operate installations that always have the flexibility and capacity necessary to attend the load requirements while maximizing the use of the economic and technical resources at the disposal of the companies.

Below are detailed the efforts developed in this field:

a. In the year 1983 an important stage began in the country's electrical development, when the first major Costa Rican effort in this field crystallized with the start-up of the La Barita Hydroelectric Plant, with a capacity of 30 megawatts and, with it, the first 138-KV transmission line.

At that time, the transmission system was growing slowly, since it was limited to a scarce set of lines that tied together the main generating plants, in order to transport their energy to the country's most important substation, located in the metropolitan area itself.

Despite the hesitant expansion of the National Interconnected System (SNI), it began embracing new settlements and incorporating grids that for years had been fed by small isolated generating stations, some of which were hydro-based, but mostly thermal.

Then in 1964 the SNI included the area of Barranca and Puntarenas on the Pacific and ten years later incorporated the Guanacaste region through transmission lines tying in the Barranca, Cañas (1974) and Guayabal (1978) substations. Similarly, and almost simultaneously, the Atlantic side was incorporated into the SNI, through the line that feeds into the Moin (1976) substation and, along the way, Siquirres (1980).

In the 1970's, the 138-KV transmission system went from 180 kmw. to 600 kmw. See Figure 1.

Up until the year 1979, the transmission system was complemented by the lines which, at a subtransmission level, fed into and interconnected with the main substations on the central plateau. As of that date, there was a ring of 138-KV lines feeding six peripheral substations. This has not only decongested energy transportation in the metropolitan area, it has also contributed to a reduction in losses in the distribution system. The old subtransmission system has lost its importance from the standpoint of transmission and has come to form part of the 34.5-KV distribution grid.

As the country's electricity consumption has grown, there has arisen a need to develop hydroelectric projects with larger capacities; unfortunately these have to be located in sites farther and farther away from the centers of consumption. It has been necessary, therefore, to introduce transmission lines carrying greater voltages, in order to achieve optimal use of investments and system operating costs. Thus, in order to transport the energy generated at the Arenal-Corobici complex (situated 170 kms. from the metropolitan area) and at the same time to hook up the Costa Rican system with those of its neighbors, a grid has been designed and is under construction, running along the "backbone" of the country, with 230-KV lines. To date, it extends 550 kms, but it will increase to 750 kms, once the interconnected line to Panama has been finished for 1984. (See Figure 4).

The interconnection with the Nicaraguan and Honduran systems was done temporarily at the level of 138 KW, with a peak capacity of 60 MW and with very satisfactory results, since it was possible to avoid the consumption of thermal-based energy in these countries and to substitute it by Costa Rican hydro.

It is projected to conclude the interconnected line to Panama for 1984. Thus, the systems of Panama, Nicaragua and Honduras would be in tegrated into one sole system, with an installed capacity totalling more than 1.5 million kW. It is also planned to interconnect El Salva dor and Guatemala, and El Salvador and Honduras. As a result, it is hoped that by 1985 all of the Central American Isthmus will been completely integrated in terms of electricity.

At the level of 230 KV, reactors have been introduced to guarantee operations free of dangerous voltage excesses and bothersome delays during re-setting and, in addition, to permit efficient control of the flow of reactives.

Similarly, banks of capacitors have been strategically located in 34.5-KV bars of certain critical substations, in order to control the transmission system losses.

Designs have also been perfected and attention to the transmission system has been intensified. By reducing the number of interruptions in service, the losses which inevitably would arise when recurring to energy transportation along alternative, longer or more congested routes can be avoided.

The power transformers are purchased taking into consideration both investment costs as well as losses produced in the kernel and win dings, to minimize total costs.

b. The System of Distribution

Up until the 1960's, electricity distribution was with 2.4,2.4/4

.16 and 7.6/13.2 KV. Over time, the last voltage range became standard for urban distribution voltage, and it was expanded in restricted fashion to certain rural sectors.

Nevertheless, the fact that the loads were remote and disperse, in a first stage of expansion for the distribution system in the rural areas (sponsored by AID, with advising from REA, the Rural Electrification Administration), led the country to introduce 14.4/24.9 KV distribution voltages in the year 1965. During this era, distribution at the 19.9/34.5 KV level took its first steps, but it still required time to mature.

Upon developing the second program of rural electrification, financed by the IDB, in 1973, the 19.9/34.5KV distribution voltage was chosen; because by this time, almost ten years after the first project, the distribution of said voltage proved competitive. Thus, the number of voltage transformations was reduced when intermediate substations were eliminated. These had not only made expansion, operation and maintenance of the system more expensive; they had made it more complicated.

Through this program, all of the subtransmission lines that were operating at this voltage have been incorporated into the distribution system. Likewise, many of the old distribution lines have been kept in service. When the conversion to the new voltage was made, they proved to have ample transmission capacity and low losses for many years to come.

Residential, agro-industrial and even tourist complexes have been fed satisfactorily along the extensive circuits which range between 100 and 150 kms. long.

Figure 2 presents the development experienced by the distribution system of the country in the 1970's. In this period, the distribution system's extension tripled by passing from barely 3000 kms. to almost 9000, of which 3300 kms. have been built with 34.5 KV.

In the metropolitan area, 19.9/34.5-KV distribution has also been standardized, thereby managing to reduce the number of circuits necessary to transport the required energy and to cover, to a certain extent, a larger area of service for each substation.

In the most extensive circuits and in those with greater loads, both at the level of 7.6/13.2 and 19.9/34.5KV, voltage regulators and capacitors have been installed in order to maintain high, uniform distribution voltage and in order to guarantee suitable voltage for all the users and to reduce, insofar as possible, the losses in the primary feeders.

Three-line secondary distribution at 120/240 KW has also been standardized; and its use has been formented in user installations in an attempt to maintain greater balance in the load of secondary circuits and, with it, better supply voltage and fewer losses.

The distribution transformers are purchased on the bas s of economic considerations; which bear in mind both the investment costs as well as the effect of energy losses during the life span. In addition, the load is constantly monitored, in order to guarantee optimal utilization and anticipate replacement in the event of overloads or underutilization.

Public lighting has been normalized with sodium steam lamps, since the economy observed has demonstrated the convenience of avoiding the expansion of illumination with mercury bulbs.

The control of the level of losses is more effective during the planning stage. Once the lines have been built, it proves more difficult to justify, in economic terms, an increase in capacity or modifications in configuration. Regulators and capacitors can be added in order to improve the voltage profile, but the energy losses will be higher than the optimum from the standpoint of opportune, effective planning.

Also, in this case, the investments in a distribution plant have covered a greater range of capacity and greater degree of redundance, although a relation of some 17.5% has been kept between distribution and overall system.

c. The National Interconnected System

In order to avoid the unnecessary use of imported fuels, both at the level of the ICE (required for the work of its thermal reserve units) or at the level of industry (as a product of the use of emergency systems), the transmission system has been granted the highest degree of reliability compatible with the reduced availability of financial resources. This would avoid, in most cases, total "layouts" and would confine the effect of inevitable setbacks to the smallest sector possible. The diversification of routes for lines, the shutdown of some rings, and the duplication of some critical installations have substantially contributed to maintaining normal operations in the rest of the system, during simple contingencies in one part of the same.

From the standpoint of energy transpor, lines with ample capacity have been installed in order to reduce from 5 to 3% the energy wasted in the high tension conductors.

Anticipating both the start-upof cooperations of the Arenal-Corobici complex with 50% of the country's generating capacity, and the interconnections with Honduras, Nicaragua, and eventually Panama, modern facilities were installed to centralized and expedite the control of the system, counting so far on a well established Energy Control Center. This work has come to substitutea dispatch system that gathered information from the generating plants and from some substations by means of telephone communications, making it difficult to handle the information opportunely under normal conditions, and almost impossible in urgent cases.

The modern Energy Control Center has an automatic system to monitor, control and acquire data directly from the main substation; and it controls the main generating units, as well as the other seven utilities of the country and the production of their major plants. Also, it has digital programs on line to simulate normal conditions and abnormal conditions. From this Center the most important work of the 230-kV and 138-KV transmission systems are controlled, as well as that of the major 34.5kV distribution grids. In addition to the generating plants, the Center supervises and controls the active and reactive power and the voltage at substations and lines, along with frequency, time error and energy exchange with the systems of neighboring countries. The Center is attended by personnel duly trained in handling the electrical system and in using the modern equipment installed for that purpose.

In order to achieve reliability and efficiency in energy transport to consumption centers, instead of continuing with the expansion of the overloaded subtransmission system at 34.5 kV, which had been serving the country's Centrall Valley for a number of yers, 138 kV branch lines were built to the peak load centers of the same, with 11 substations at this input tension for an equal number of centers, with a capacity of 30 to 100 MVA each and a ring of 138 kV around the Metropolitan Area, also located within the Valley.

The subtransmission system replaced by a study 138 kV- system came to form part of the 34.5 kV distribution grid of the distributing firms of the country. That subtransmission, working as distribution feeders with suitable capacity margins, makes it possible to defer the investment in expansions of the center substations, since two or three of them are capable of transporting important loads between centers, in the case of temporary service shutdowns in one of the substation transformers or in the case of the temporary breakdown of one of the radial 138-kV lines.

In order to confirm the efficiency of the tran mission system, a good number of kWh meters have been installed at suitable locations at the beginning and end of the high-tension lines, as well as at the entrance and exit of the power substations.

5. Merits of the conservation policies

In viewing the conservation policies that have been applied in Costa Rica and keeping them in proportion since it is a small country with very limited resource it is useful to underscore those that have had more impact.

For this purpose, the behavior of the system over the last few years will be investigated. Figure 3 presents the annual generation and demand of the system.

Figure 4 presents the behavior of system losses at the level of transmission and at the level of distribution.

It is useful to recall that the distribution at 19.9/34.5 kV was intensified as of 1975 and that the 138-kV ring of the metropolitan area went onstream in the year 1979.

The results obtained are quite noteworthy, taking into account that the distribution system was expanded from 3000 to 9000 kW between 1970 and 1982 (see figure 2), and that the load increased (as can be seen in Figure 3), while distribution system losses were consistently decreasing as of 1971, from 15% to 8.6% with a view to 7% in the future.

The results of the efforts in the area of energy transmission are equally important, since losses have managed to drop from values of some 5% to nearly 3%, despite the marked increased experienced by the load of the system (see figure 3.) It can be concluded that the measures adopted have also been efficient in the field of energy transmission.

According to the level of generation achieved in Costa Rica in recent years (2800 GWh/year), 9% economy of losses, such as that attained in transmission and distribution, represents a block of energy of some 250 Gwh/year, which instead of being dissipated in the conductors can be put to better use, postponing new generating plants and avoiding the consumption some 65,000 m^3 of oil or supplying the needs of new national or international markets.

Below are presented some policies or provisions that, in our opinion, have brought about major effects on energy conservation in the electric power system.

a. Institutional Framework

After the creation of the ICE, and on account of the work that it undertook as the directing entity, the efforts made at one time by as many as 40 utilities, spread throughout the national territory, came to be consolidated in only 8. This change brought with it an environment propitious for accomplishing rational management and development of the electric services provided in Costa Rica.

Within these circumstances and consistent with the national development policy it has been possible to undertake tasks such as the following: geographical projections of the national electricity market, independently of the areas of service assigned to each power company; conception, planning and overall development, under the responsability of ICE, of the sources of generation and transmission required by the different centers of consumption; conception and planning, within uniform criteria of the distribution grids required by the country's users; standards for services and tariff structures uniform for clients of the different power companies, under the responsibility of the ICE and the country's regulating agency (National Electricity Service); distribution losses; simultaneous funding, joint purchases of goods and services, coordinated development of the reconstruction, construction and and urban and rural distribution networks, for the various companies; coordinated plans of operation for plants, lines, substations and distribution grids. Each one of these tasks is executed within the criterion of making the best possible use of the available financial resources and the best utilization of the energy to be transported

b. The Transmission System

The losses in the transmission system were reduced from 5% to values of around 3% of the energy generated between 1971 and 1981.

In order to reduce transportation losses, the Energy Control Center keeps the voltage in substation bars and delivery points at 5% above the rated voltage, through the use of capacitors, capacitive reactance in the lines, automatic derivation changers in the transformers and self-transformers at the large substations.

Likewise, through suitable equipment, the transmission losses are reduced by generating power as close to the point of consumption as possible, and in line with the reactives that the consumers and distributors demand, instead of producing that power in the generating plants. Through fines on account of low power factors and promotional compaigns, the typical power factors at the points of delivery to the distribution feed lines are above 97% and those that are recorded at the exit of the generating plants fluctuate around 100%.

c.- The Distribution System

The conversion of voltages and the expansion of the distribution system to the level of 19.9/34.5kV is the factor that has most influenced the reduction in losses demonstrated by the Costa Rican system in recent years.

The use of low-loss transformers and voltage regulators and capacitors, in order to maintain a high, uniform voltage in the primary feeders, also assures a notable reduction in losses.

The opportune, solidly-grounded planning of the distribution system has made a positive contribution to energy conservation.

d. The Consumption Sector

In order to make efficient use of the power system, mechanisms are available to contribute indirectly to improvements in the load factor.

Thus, tariffs have been established to favor those whose work schedules fall outside peak hours.

Also, bonuses have been granted through special rates to those seasonal industries that preferably work during the rainy season, when energy production takes place in the plants closest to the centers of consumption.

Furthermore, preferential tariffs have been implemented for industrial heating outside peak hours, seeking to avoid the importation of fuel and to make better use of the transmission system.

For those consumers with few resources, there are rates geared to fostering the efficient use of energy in the residential sector.

Moreover, there are advisory units for the users, which are dedicated to disseminating effective energy-savings practices through the use of common equipment and tools, through the correction of the power factor, and through the use of special tariffs.

Due to the reduced demand of the current market and limitations of an economic nature, mechanisms have not been set into motion for managing loads; nevertheless, with the aforementioned measures, certain advances are being made in this regard.

6. CONCLUSIONS AND RECOMMENDATIONS

1. Notwithstanding the fact that the attention of the country has been primarly concentrated on the optimal use of its reservoirs for hydroelectric generation, the Costa Rican experience has demonstrated that rational use of energy in the transmission and distribution of electricity can and should be a reality.

2. In order to guarantee the optimum utilization of the power system and in order to minimize transportation losses, it has been proven that it is useful to have an entity at the national level in charge of conceiving, planning and developing the sources to generate electricity and in charge of the transmission system, so that it can be the guide in the area of distribution grids and at the same time spur the execution and joint financing of new projects in this field.

3. The maintenance of high voltages within permissible limits, and the generation of the necessary reactives as close as possible to the centers of consumption, can contribute to avoiding waste in energy transportation; furthermore, the addition of lines with ample capacity geared to decongesting energy transport, has proven to be a contribution towards substantial reduction in losses.

4. In the field of distribution, it has been proven that the level of 19.9/34.5kV voltage not only avoids intermediate transmission stages but also permits the coverage of more extensive areas of service and appreciable reductions in losses. The use of low-loss transformers and voltage regulators and capacitors has also contributed to achieving more efficiency in this area.

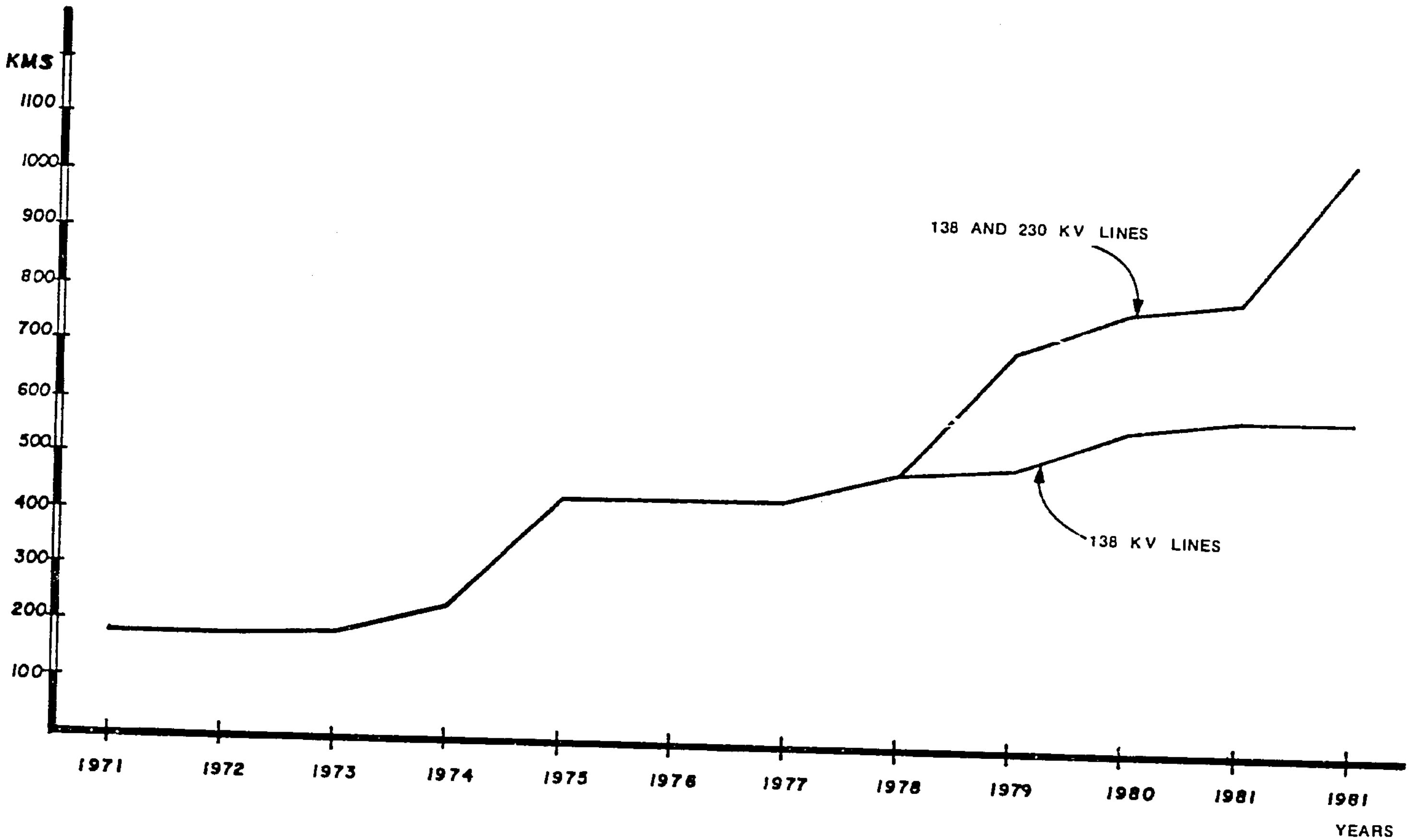
5. The management of loads through indirect policies such as preferential rates outside of peak hours has had a positive influence on certain industrial sectors.

6. Even in systems with substantially hydro-based electric power generation, such as that of Costa Rica, the savings in transmission and distribution losses represents an important amount of energy, which makes it possible to defer the installation of a new power plant or to earn important sums of annual revenues from the exportation of that same energy to the markets of neighboring countries.

INDEX OF FIGURES

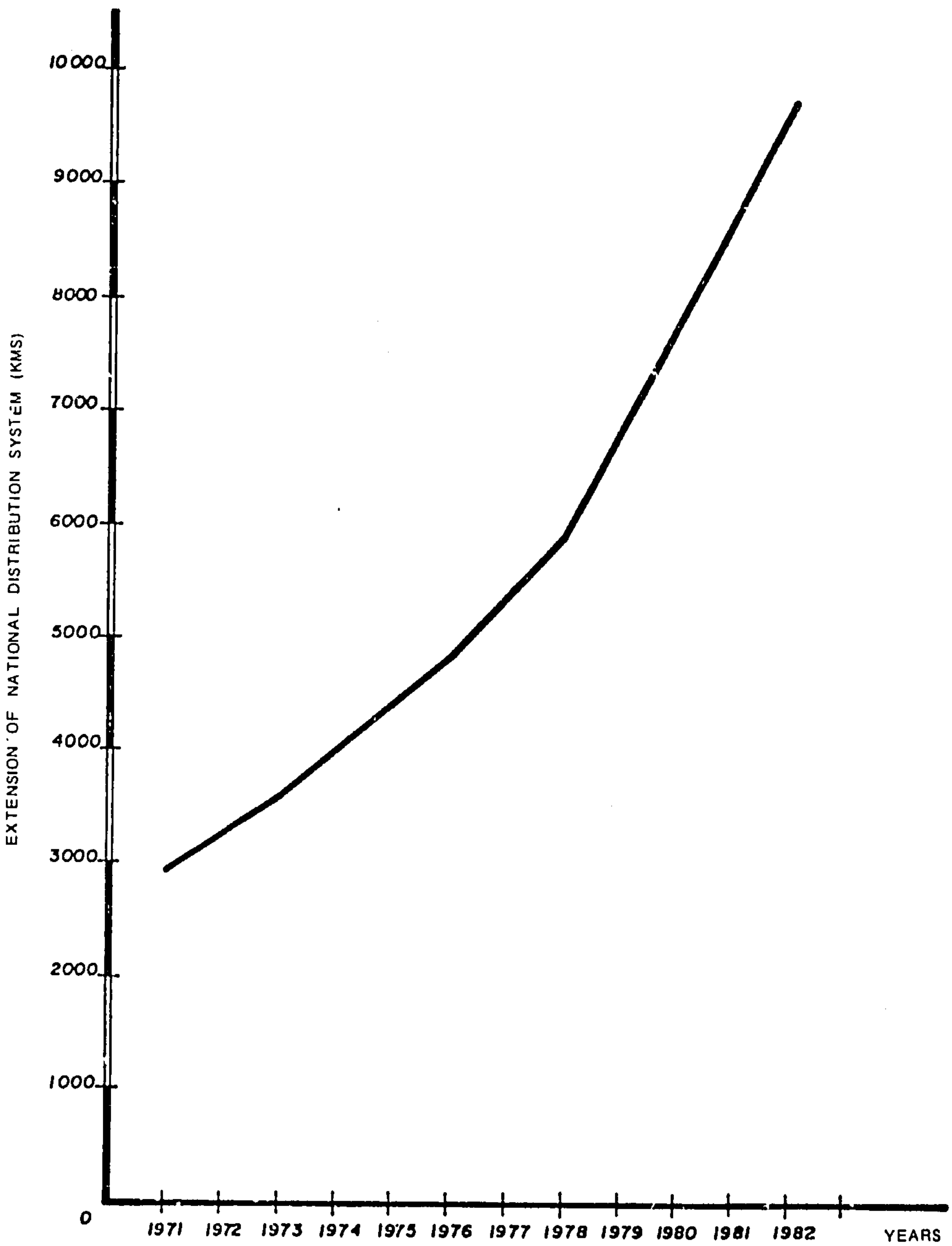
Graph 1

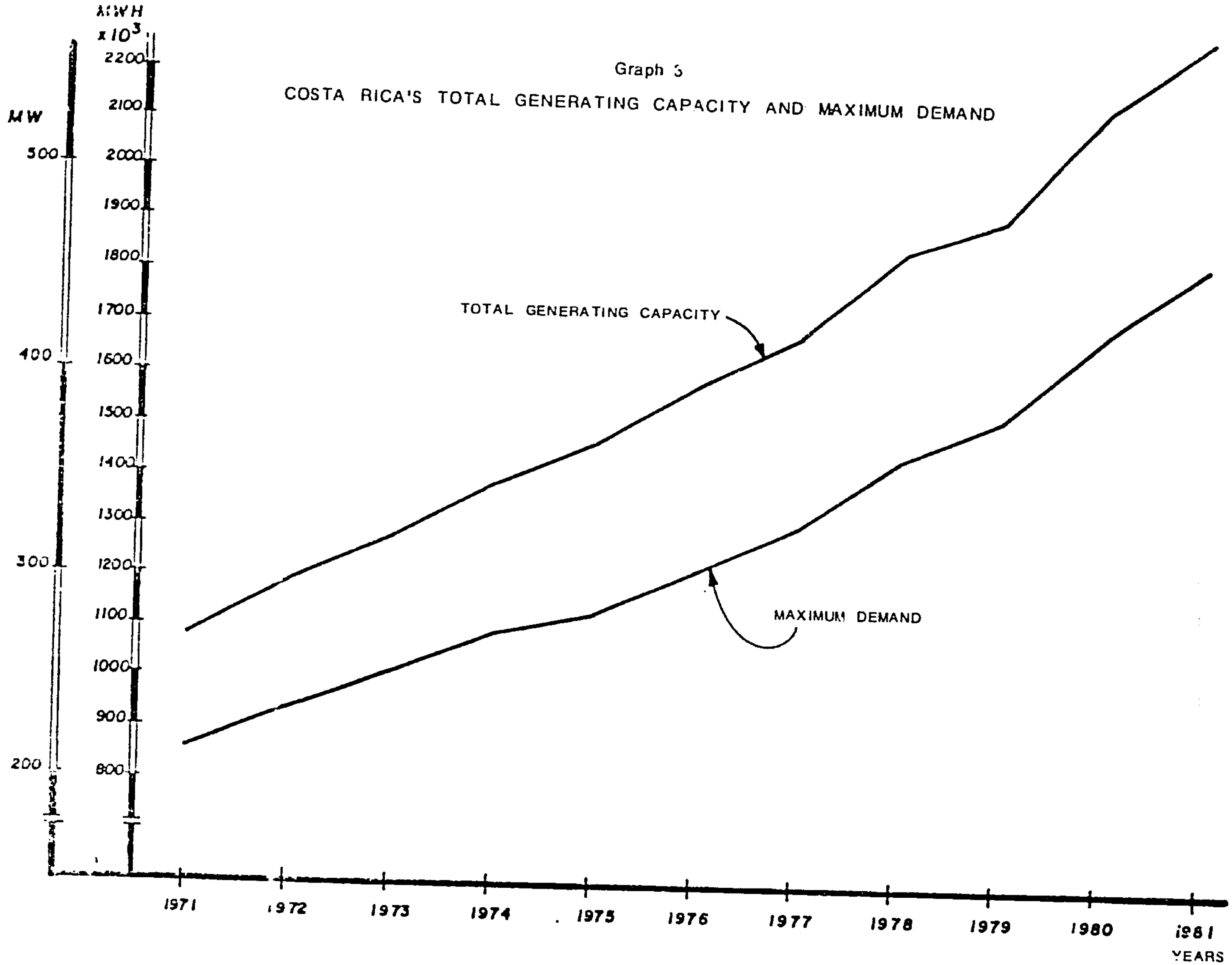
COSTA RICA TRANSMISSION SYSTEM



Graph 2

EXTENSION OF DISTRIBUTION SYSTEM




Graph 3
COSTA RICA'S TOTAL GENERATING CAPACITY AND MAXIMUM DEMAND
MW
500
400
300
200
MWH x 10^3
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
TOTAL GENERATING CAPACITY
MAXIMUM DEMAND
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
YEARS

Graph 4

ENERGY LOSSES IN TRANSPORTATION AND DISTRIBUTION

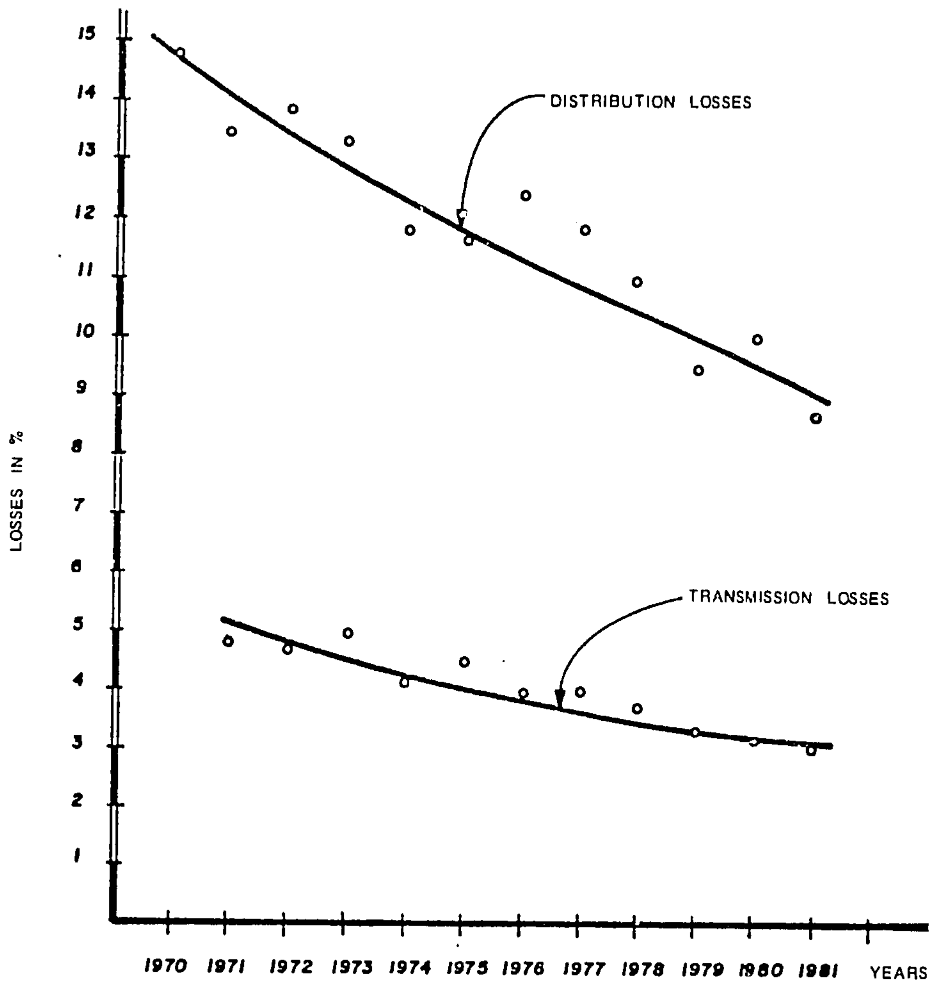
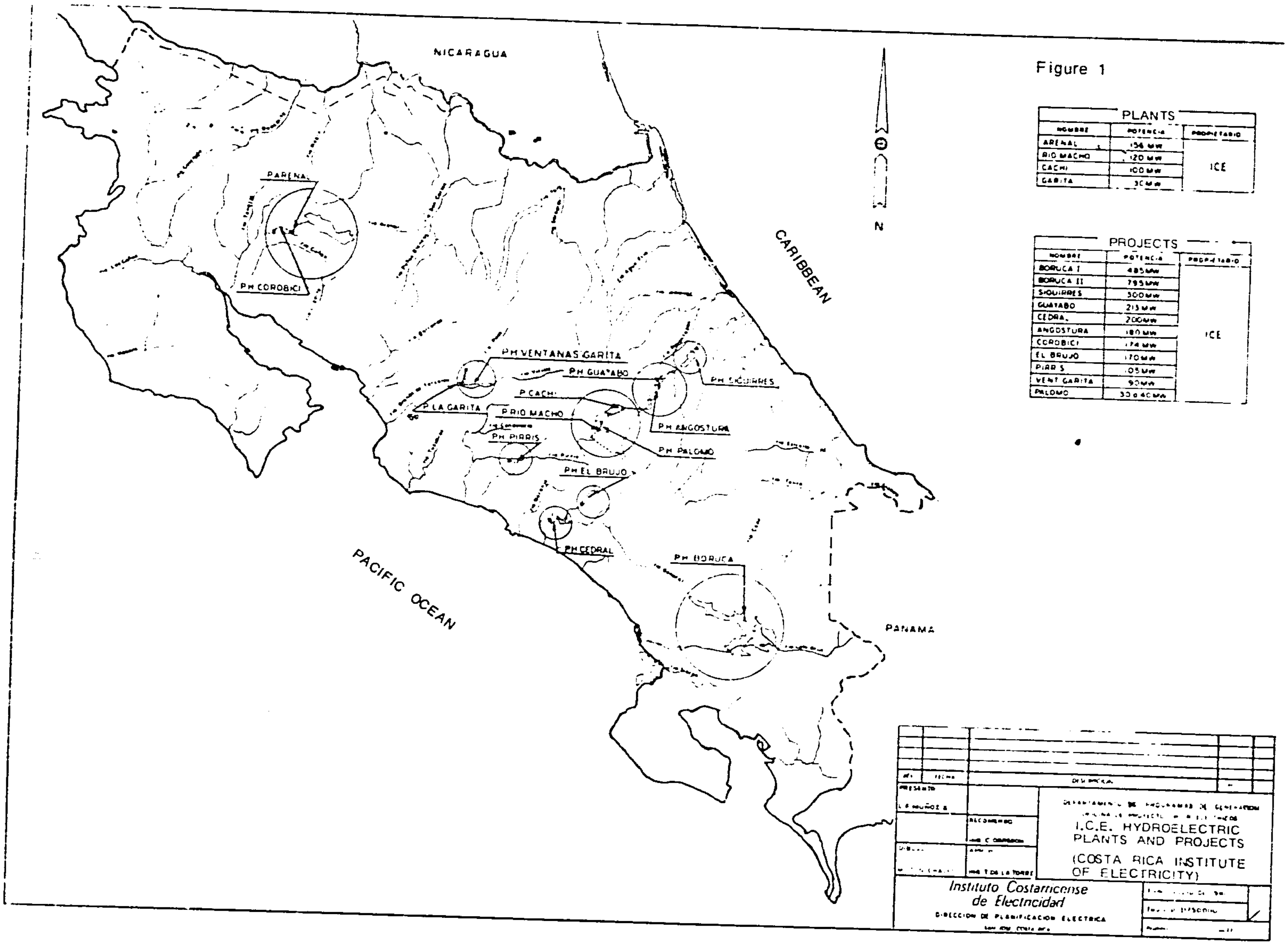


Figure 1



PLANTS

NOMBRE	POTENCIA	PROPIETARIO
ARENAL	156 MW	ICE
RIO MACHO	120 MW	
CACHI	100 MW	
GARITA	30 MW	

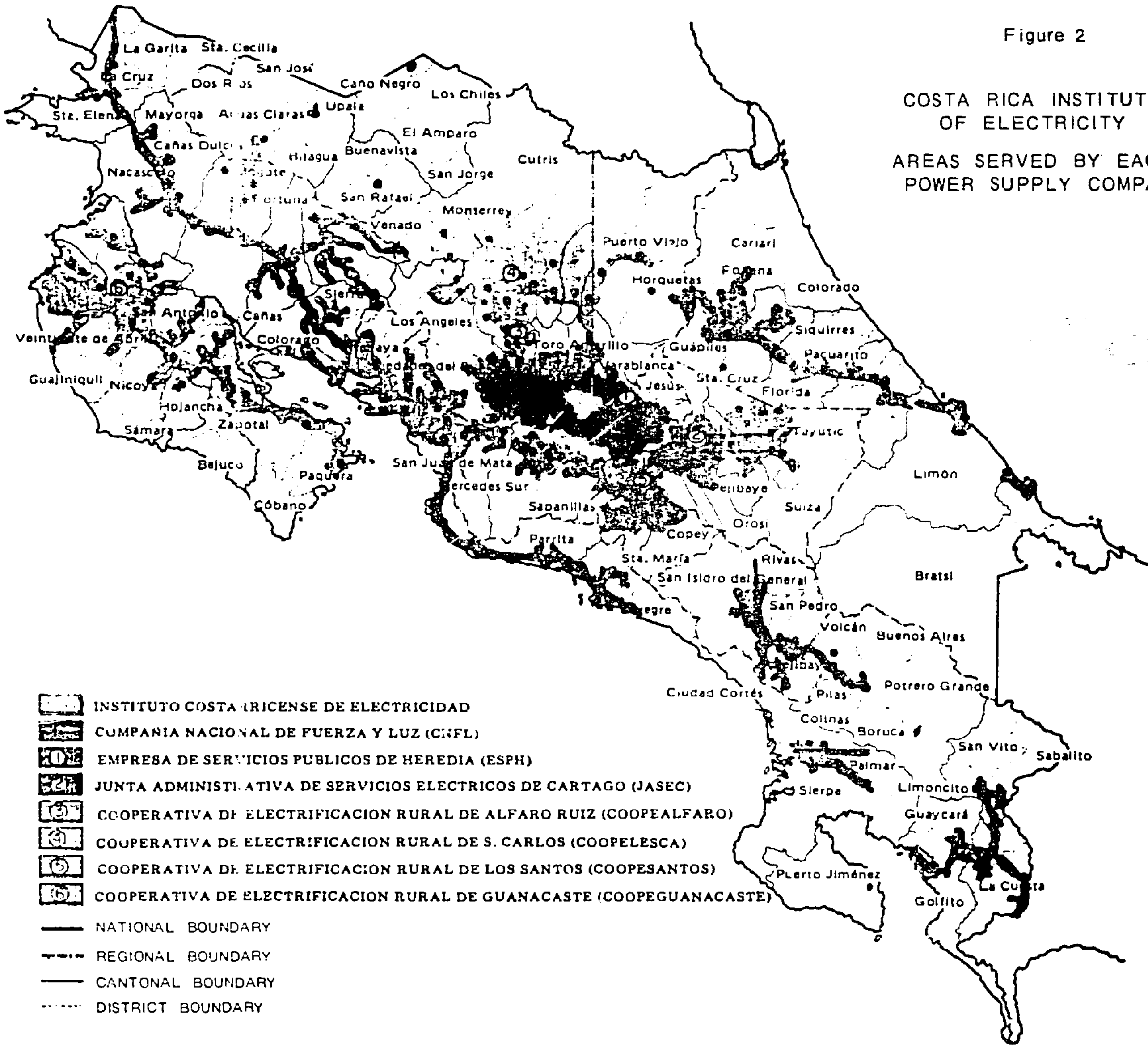
PROJECTS

NOMBRE	POTENCIA	PROPIETARIO
BORUCA I	485 MW	ICE
BORUCA II	795 MW	
SIQUIRRES	300 MW	
GUATABO	213 MW	
CEDRAL	200 MW	
ANGOSTURA	180 MW	
COROBICI	174 MW	
EL BRUJO	170 MW	
PIRRIS	105 MW	
VENT GARITA	90 MW	
PALOMO	30 a 40 MW	

Figure 2

COSTA RICA INSTITUTE OF ELECTRICITY

AREAS SERVED BY EACH POWER SUPPLY COMPANY

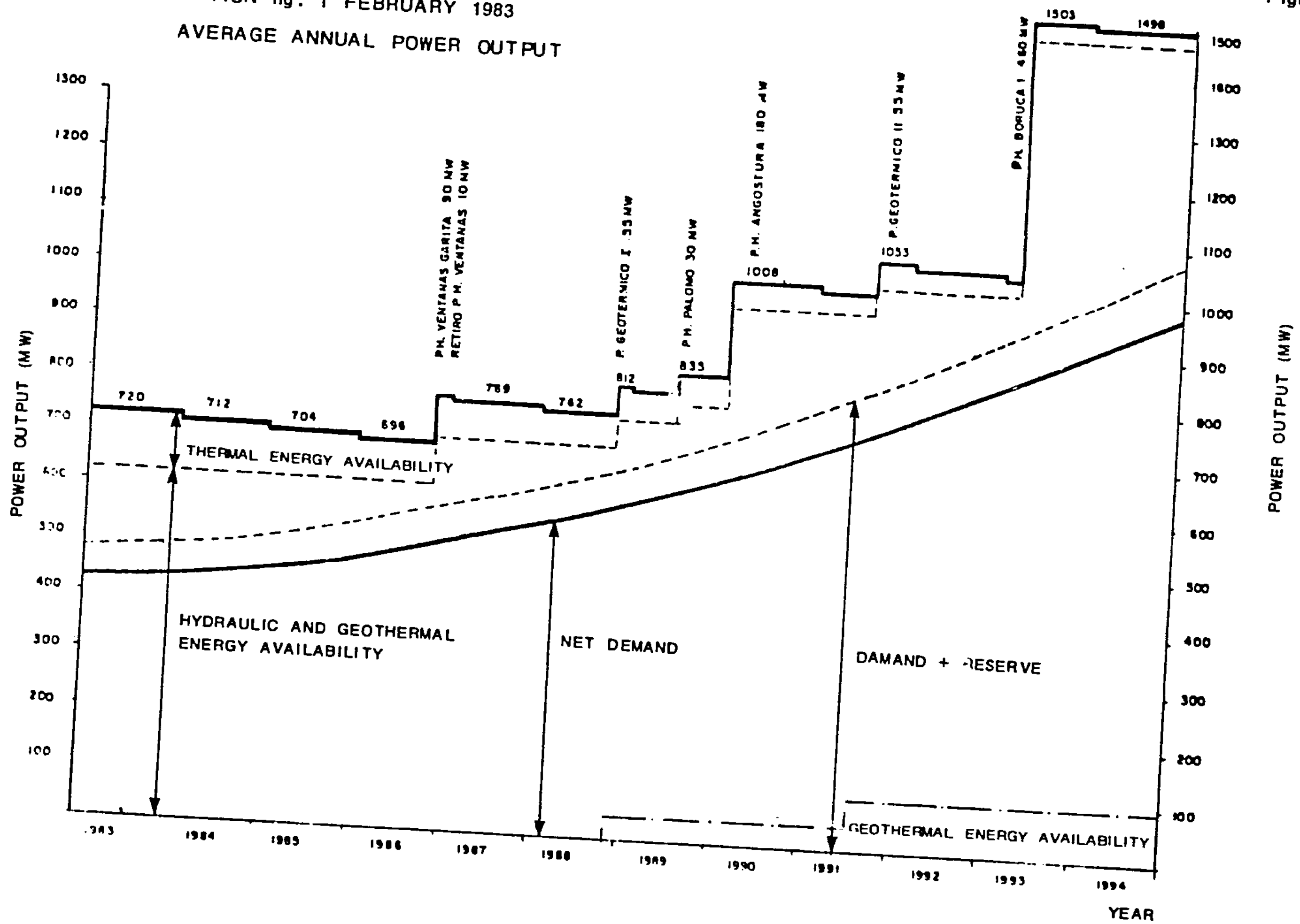


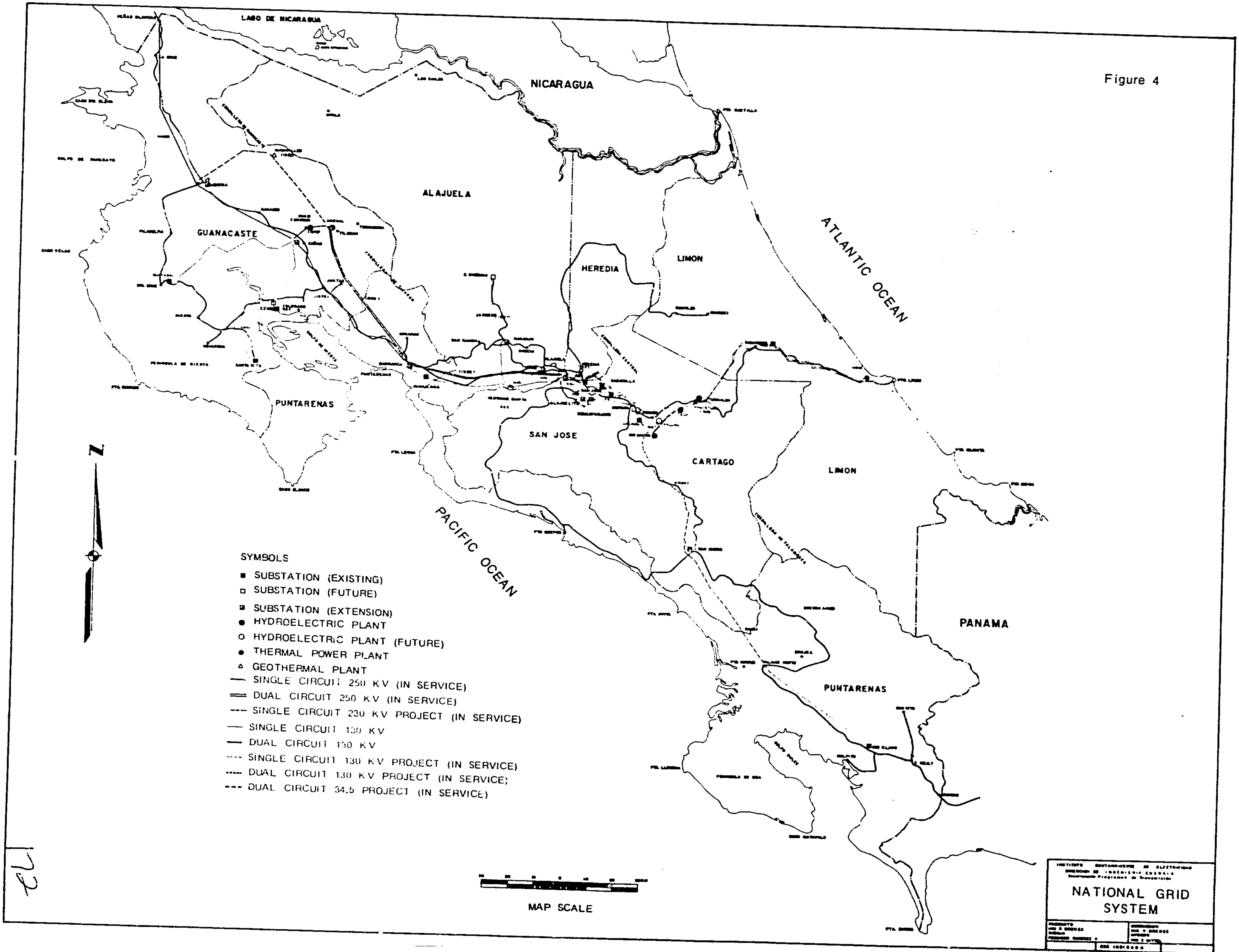
NATIONAL GRID EXTENSION PROGRAMME

OPTION hg. 1 FEBRUARY 1983

AVERAGE ANNUAL POWER OUTPUT

Figure 3





LAGO DE NICARAGUA
NICARAGUA
ALAJUELA
GUANACASTE
HEREDIA
LIMON
ATLANTIC OCEAN
PUNTARENAS
SAN JOSE
CARTAGO
LIMON
PACIFIC OCEAN
PANAMA
PUNTARENAS
N
SYMBOLS
SUBSTATION (EXISTING)
SUBSTATION (FUTURE)
SUBSTATION (EXTENSION)
HYDROELECTRIC PLANT
HYDROELECTRIC PLANT (FUTURE)
THERMAL POWER PLANT
GEOTHERMAL PLANT
SINGLE CIRCUIT 250 KV (IN SERVICE)
DUAL CIRCUIT 250 KV (IN SERVICE)
SINGLE CIRCUIT 230 KV PROJECT (IN SERVICE)
SINGLE CIRCUIT 130 KV
DUAL CIRCUIT 130 KV
SINGLE CIRCUIT 130 KV PROJECT (IN SERVICE)
DUAL CIRCUIT 130 KV PROJECT (IN SERVICE)
DUAL CIRCUIT 34.5 PROJECT (IN SERVICE)
MAP SCALE
NATIONAL GRID SYSTEM

Figure 4

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Rational Use of Energy and Oil-Substitution with Particular Emphasis on Electric Energy in the Federal Republic of Germany

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1. Introduction

It would be like carrying coal to Newcastle to want to explain in this circle the reasons why all nations of the world are urged to aim their energy policy at the principle which is already indicated in the topic on which I should like to make a few remarks, namely:

Economical and rational use of energy and oil substitution in electricity generation and consumption.

I am most grateful to the organizers and especially to OLADE for being permitted to report today on the experience of the Federal Republic of Germany in this field. On the basis of this specific experience I shall attempt to demonstrate that it has been possible to achieve remarkable successes in our efforts to utilize primary energy rationally, also in the electricity generating sector and that, furthermore, even today there are many technologically matured possibilities for advancing us a good deal further along the path which we have taken.

Consideration of the present correlation between non-renewable energy reserves and their exploitation worldwide (Fig. 1) reveals a distinct disproportion in the percentage figures. The current preference for mineral oil and natural gas bears no relationship to the structure of their reserves. Coal and nuclear power are the important energy sources of the future.

When we speak of German experience, we must of course be fully aware that these relate to the specific conditions of an industrialized nation which has been transformed over the period under consideration from a country independent of energy imports, i.e. self sufficient, into a country which imports roughly 50% of the primary energy sources used.

Thus the knowledge gained and consequences drawn cannot of course be applied to other countries and regions without qualification. I am, nevertheless, optimistic enough to maintain that an optimum energy strategy which not only helps the individual nation but also will enable sparing use of the finite energy reserves of the Earth ultimately on a worldwide basis, can be found for any national economy provided that there is a sufficient input of technological knowhow, understanding for national economic interrelationships, well-considered investment and motivation of the people involved.

2. The Energy Situation of the Federal Republic of Germany

The primary energy consumption of the Federal Republic of Germany is about 400 million tonnes CE. Figure 2 shows the 1979 figures for energy flow in final energy and useful energy. The corresponding figure for primary energy was about 370 million tonnes CE in 1982. The relationship between the figures on the diagram remains almost unchanged. The drop in consumption towards 1979 is in essence governed by 4 factors:

- Economic recession
- Mild weather in the winter past
- Structural changes in a number of energy-intensive branches of industry
- Energy saving

Figure 3 demonstrates why mild weather, for example, can significantly affect the energy balance:

Of the final energy consumption amounting to approx. 270 million tonnes CE the lion's share, namely 73%, devolves upon the heating sector in the form of process heat and space heating. The remaining 27% are used for power and lighting application. Thus it is logical that in Germany even the short and medium-term energy saving capacity in the heating sector is considered to be favourable.

Please allow me to present you a further comparison of facts and figures: (Fig.4).

In 1981 approx. 370 million tonnes CE were consumed in the Federal Republic of Germany of which 43% took the form of imported mineral oil and constituted a burden of about 70,000 million DM on the German balance of foreign exchange payments. The corresponding figures for 1973 are:

About 340 million tonnes CE of which imported mineral oil made up 52% entailing foreign exchange payments of 15,000 million DM.

What do these figures tell us?

Firstly, energy consumption growth rates, which were 4.8%p.a. between 1960 and 1970, have slowed down appreciably since 1973.

Secondly, the percentage share and absolute quantity of imported oil have decreased significantly.

Thirdly, the oil import bill of the Federal Republic of Germany nonetheless rose by a factor of nearly 5 over this period.

Similar conclusions can no doubt be drawn for any other oil importing nation. Even a simple comparison of this nature makes it clear to us how great the effect of developments on the world oil market has been on the world economy. However, it must be pointed out that Germany was in a comfortable starting position compared with other countries in 1973 when the world energy market called for rapid and efficient adaptation of the individual national economies under almost dramatic conditions. I should like to back up this statement with the following theses:

(1) Since the start of its industrialization in the last century Germany has been a nation of high energy costs. Domestic hard coal, which was the mainstay of the energy supply up to the advance of cheap mineral oil in the sixties, has to be mined at high cost in geologically difficult deposits. High energy costs have favoured the invention and introduction of energy-saving technologies. Figure 5 shows the development of the specific energy input of German industry for a product value of 100 DM. It is apparent that the downward trend is almost uniform and flattens out only recently. The significance of electricity rises in proportion to the supplantation of fossil final energy. This desirable development is considered in greater depth in the following section. Furthermore, it may be seen from this diagram that a rising electricity consumption may, under very specific conditions, be a suitable means of reducing the specific primary energy consumption. Figure 6 shows an international comparison of developments between 1973 and 1978. Here it becomes clear that the European nations fare well in comparison with the USA, for instance, and this is particularly true of Germany.

(2) Flexibility of the "energy consumption system" as a whole was guaranteed by a maximum of "free market forces" and a minimum of administration. Experience has taught us that the necessary adaptations of the past decades were accomplished well largely by reliance upon the forces of the free market economy in Germany which, for example, can also be corroborated by a comparison of the present position of the German industry, with the international market. Administrative interference which generally cause controls, monitoring and administrative effort and frequently lead to ponderousness instead of effectiveness were kept to a minimum. Thus, for instance, unhindered supplantation of domestic coal by cheap mineral oil in the years up to 1973, which purely according to the rules of the marketplace could well have been possible because of their prices, was restricted by statutory measures since domestic resources were to be retained for political and strategic reasons.

In some of the previous diagrams I have attempted to show the organisation of energy flows in the Federal Republic of Germany. Let us now take a look at the development of the shares of the individual primary energy resources. Figure 7 shows the figures of the official 1981 energy program of the Federal Government.

The target of reducing the oil share to about 1/3 may be achieved in essence by taking 3 measures:

- Further improvement of energy utilization. It appears possible to lower the ratio of energy consumption increase to gross national product growth from 0.8 (average for 1965 - 1980) to 0.5 by the end of the century, i.e. only 1/2% rise in energy consumption for every 1% increase in gross national product.

- Raising the share of nuclear power, especially in base load generation, to 17% of the primary energy input.

- Continuous raising of the share of hard coal; this entails considering the import of coal once the domestic mining capacity has been exhausted. Hydroelectric power and German lignite are to be used to the maximum possible extent. The same applies to natural gas with new supply contracts with the USSR serving as the primary substitute for contracts which are coming to an end.

In similar form, Figure 8 shows the development of final energy consumption with the forecast figures in turn portraying the scenario.

Electric energy has increased its share amongst the final energy forms impressively; this is explained by the fact that it is a clean, economical, unproblematic and versatile medium. Let me remind you of the graph shown in Figure 5 which underlines this statement.

Let us now turn to the question of which primary energy sources were in the past and will in the next few decades be of significance in Germany in the generation of this final energy form which is so convenient for the user. Thus I come to the 3rd section of my talk:

3. Electricity Energy in the Federal Republic of Germany

Figure 9 emphasizes one of the statements made in the preceding section:

The self-sufficiency of the Federal Republic mentioned there with respect to primary energy until well into the Fifties is, of course, reflected in the dominance of coal in the electricity generating sector.

Just as mineral oil gradually captured the heating market in the Federal Republic by virtue of its low price, as well as leading in the transport sector, it gained ground in the electricity generating field and peaked out in the early Seventies.

The future trend is clearly discernible even if the figures will in detail be subject to certain modifications - as in the forecast of the 3rd update of 1981, Medium Variant, of the Energy Program of the Federal Republic; this is in particular to be expected with the figures for gross electric generation which are strongly affected by industrial demand.

However, the latest figures for 1982 (Fig. 2) confirm that developments are going in the right direction in that the percentage shares of heavy oil and natural gas have already dropped further than estimated in the Energy Program:

Heavy oil	in 1982 already below 3%
Natural gas	below 10%

This success was made possible by the considerable increase in the shares of nuclear energy and lignite. The role of nuclear energy warrants special mention in that 10,360 MW installed capacity, i.e. approximately 14% of the total public capacity of 74,900 MW, already generated almost 21% of the gross generation. The pr[illegible]dition for such operating results are high reliability and availability of nuclear power plants which render possible the use of nuclear plants at full power in the base load range right around the clock.

I should like to make a few more remarks on this point:

In a system comprising power plants using different primary energy forms and having various unit capacities, base load is usually generated by the plants with the lowest power generating costs. These are generally those plants in which the share of fuel costs in the generating costs are lowest, i.e. in Germany hydropower, lignite and nuclear power. Figure 11 shows the load diagram for the year 1980 from which it becomes apparent that the principle mentioned has not yet been adequately realized in Germany. Hard coal-fired power stations are still being employed in the base load range in spite of their high fuel costs. The electricity generating structure desirable for the Federal Republic of Germany involving hydropower, nuclear power and lignite for base load generation, hard coal for the mid-range and gas and oil for peak load is shown in Figure 12 as the specified objective for the turn of the century.

Of the additional nuclear capacity necessary for this purpose units of about 14 GW are already in construction with the commissioning dates planned for within the next 7 years.

Following on from the consideration of the shares of the various primary energies in power generation I should now like to direct your attention briefly to the distribution and use structures although I do not wish to discuss in detail a complicated representation such as Figure 13 - the electricity flowchart of the Federal Republic of Germany in 1981. A few comments shall suffice:

- The share of industrial generation is about 17% of total generation;
- About 1/3rd of industrial generation is fed into the public grid, 2/3rds are consumed in industry directly;
- The predominant share of industrial consumption is drawn from the public grid;
- Of the industrial customers the chemicals industry is the main consumer;
- Household, trade, traffic, agriculture, etc. now consume more electricity from public generating stations in Germany than industry;
- Internal consumption by power plants and transmission losses have been minimized in the course of time.

I should like to take this last remark as the introduction to the next section:

4. Energy Savings and Substitution of Fossil Fuels

Let us first consider the electricity sector. Savings can in this instance be achieved in the fields of:

- Generation
- Distribution
- Consumption

I should like to show you the development in power generating efficiency in Germany in the next diagram (Fig. 14). The major successes in the effort to use energy rationally were achieved well before the period of high oil prices; this underlines the statement in Section 2 on Germany's traditionally high energy costs. This development, as far as the average efficiency of all plants operating on the interconnected grid is concerned, has come to its final conclusion since an increase above the value achieved of 37.5% is impossible because of the increased use of nuclear power plants.

What are the engineering measures which have in the past brought about this remarkable reduction in specific energy input?

The following points are worthy of mention, in particular:

(1) Discontinuation of the "range system" in favour of the straight "unit configuration", i.e. instead of several boilers operating on common steam headers, even in some cases at different pressure levels, feeding to a number of turbines, one boiler is paired with one boiler.

(2) Raising of the main steam pressure to between 125 and 180 bar and introduction of reheat.

(3) Increase in unit capacities.

(4) Improvements in materials technology, especially in boiler construction, to allow main steam and reheat temperatures of up to 538°C.

(5) Introduction of the forced-circulation boiler and of variable pressure operation entailing significant reduction in start-up and shut-down losses and low-load losses.

(6) Improvements in burner and combustion technology, control loops, etc. resulting in improved boiler efficiencies.

(7) Increased sophistication in the arrangement of the water/steam cycle, e.g. larger numbers of regenerative feed heating stages, improved terminal temperature differences of heat exchangers, reduction of pressure losses in piping, etc.

(8) New power plant concepts such as combined-cycle gas and steam turbine plants and combined heat and power.

Please allow me to expand upon the last point with a few examples:

The power generating efficiencies of conventional stations lie between 30 and 40% depending on steam conditions, circulating water temperature and arrangement (Fig. 15). Process heat or heating steam can be generated at about 60 - 65% by combustion of fossil fuels. The combination of both in backpressure plants or in extraction condensing turbines enables primary energy utilization of up to and over 80%. Typical example configurations are shown in Figures 15 and 16. Figure 17 shows a comparison of the typical energy flowcharts with complete utilization of exhaust heat assumed in the instance of the backpressure variant (left-hand variant).

On the subject of combined-cycle gas and steam turbine plants I should like to describe two developments which are now certainly considered worldwide to be the most widespread plant types: (Fig. 18)

Marked as type "A" on this diagram is a conventional fossil-fired steam power plant equipped with a topping gas turbine. The gas turbine exhaust gases contain sufficient oxygen to serve as combustion air for the steam boiler. Thus the reject heat of the gas turbine process can be used down to the vent air temperature which is governed by the dewpoint, i.e. between 130 and 150°C.

The last-named principle also governs the arrangement of type "B". In this instance the reject heat of one or more gas turbines is used to generate steam without supplementary combustion of fossil fuels.

Both alternatives possess advantages and disadvantages in direct comparison with one another. What they have in common, however, is that they present a significant improvement in primary energy utilization by comparison with conventional steam power plants. Figure 19 shows that type "A" excels in its almost constant high plant efficiency between full load and approximately 50% load while with type "B" a high full-load efficiency can be achieved and, where several gas turbines are installed, considerable improvements over normal steam power plants are possible even at part load by shutting down individual generating units. Other advantages of type "B" are its short construction time and low investment costs.

Positive operating experience is available both in Germany and worldwide for both plant types. Development projects are in progress in Germany and other countries to use gas from coal gasification plants in combined-cycle plants to reduce the combustion of valuable natural gas and oil distillates.

New power plant concepts and new technologies are at present being studied with the aid of the Federal Government also with a view to the serious problems of environmental pollution: one of these projects is a prototype power plant which recently went into operation in Völklingen (Fig. 20).

In this plant, a number of new technologies are being combined and tried out on a commercial scale, e.g.:

- Combined gas and steam cycle;
- Fluidized-bed combustion of high inerts coal which preheats the combustion air to the gas turbine;
- Flue gas desulphurization system located in the cooling tower;
- Low-temperature heat utilization for district heating.

The efficiency of the plant is to be over 39%.

Secondly The losses incurred in the transmission and distribution of electricity were also reduced in recent years. As Figure 21 shows, the savings achieved in the last few years were not as great as those of the Fifties and Sixties.

The following measures contributed to the reduction of losses on the geographically small and densely interconnected grid in Germany:

- Increased line cross-sections;
- More interconnection;
- Construction of new powerplants closer to consumer centres;
- Transition to higher transmission voltages (380 kV in addition to 110 and 220 kV);
- Dropping of intermediate voltages;
- Installation of fully enclosed switchgear which enabled transmission at high voltages into consumer centres.

It was not possible significantly to reduce losses further in spite of continued increased in the capacity of grid installations. We must accept that with losses of about 5% on the German interconnected grid a technical/economic limit has been reached.

Thirdly There is no "ingenious" answer to the problem of reducing electricity consumption that would afford major economies with, as it were, a single stroke of the pen.

Indeed, we consider this problem to be a challenge to the engineer to attain measurable results by means of a multitude of improvements to be gradually implemented in all areas of the use of electricity.

In this field, electronics will play a key role in future in optimum process control. Indeed there are estimates which anticipate energy savings of about 15% from the expedient use of electronic controls. One example may serve to illustrate this:

Most energy and electricity consuming plants operate at variable load.

Savings can be made by controlling energy input as a function of load or production capacity. Pumps, compressors, fans, etc. mostly operate on the throttling principle (Fig. 22). A desired reduction in mass flow by 20%, for example, can be effected either by means of a throttle valve or by a change in speed. In the first instance the energy consumption of the motor is about 90%, with electronic speed control the power requirement could be reduced to about 58% of this value; thus electronic speed control saves approximately 42% electric energy.

Another example:

Electric railways are frequently still equipped with braking resistors which convert kinetic energy into heat which is then dissipated into the environment via the engine roof. New developments in locomotives and underground trains enable feedback of braking energy into the grid. The regenerative brake permits electricity savings of between 20 and 30% in particular in suburban service systems with high top speeds and short distances between stops.

Let me now leave the subject of the application of electric energy and say a few words on energy saving in the traffic and heating sectors.

- In the Federal Republic approx. 25% of the mineral oil used is consumed by road vehicles.

- Even consumption decreases of only a few percent would bring about noteworthy savings in petroleum products in terms of absolute quantities. Here as well, electronics and microelectronics can already help. Electronic ignition, electronic ignition timing, electronically controlled fuel injection are just a few key words. The savings potential of these measures alone is estimated at about 15 to 25%.

- More than one third of final energy in the Federal Republic of Germany is used for heating purposes (Fig. 3). Improved thermal insulation of residential and office buildings opens up a broad field of possible savings. On the one hand, continued extension of district heating systems entails benefits through the principle of combined heat and power and hence through higher efficiency of heat generation, on the other hand, this is a proven method of replacing imported oil with domestic coal or even in future with reject heat from nuclear power plants.

- Since about 76% of the final energy consumption of industry is required in the form of process heat, this area affords, of course, the broadest scope for possible savings, especially through:

  - Direct utilization of reject heat as process heat;
  - Utilization of reject heat for space heating;
  - Generation of mechanical and electric energy from reject heat;
  - Heat recovery by means of heat pumps.

- This conference features many lectures on the special possibilities of rational use of energy in various branches of industry; I shall therefore confine myself to the key words mentioned.

Finally, please allow me to summarize the experience and planned objectives of the Federal Republic of Germany on the subject of my statements:

- Electricity, by virtue of its versatility, is a final energy form whose significance will further increase in the future. It will further penetrate the traffic and heating sectors. In principle, it affords further possibilities for rational energy utilization and a broad spectrum for the substitution of fossil fuels generally and of petroleum products in particular.

- Fossil energy resources are spared by the increased utilization of nuclear energy in the form of light water reactors and by the systematic development of new reactor types such as the fast breeder and high temperature reactor.

- Nuclear process heat may in the future lead to low-price products and economic coal utilization in the important field of coal gasification and liquefaction.

- Additive energies such as solar, wind or biomass will not be able to provide a significant contribution to the energy supply in Germany in the next 20 years. Nevertheless the development of these technologies in the industrialized nations must be further advanced in the interests of user nations in which other conditions with regard to climate, geography and "energy flux" prevail.

- The objective of reducing the mineral oil consumption of the Federal Republic to half of the level of 1980, that is to about 150 million tonnes CE, by the year 2000 appears achievable through consistent utilization of the potentials of:

  - Energy saving;
  - Direct substitution with coal;
  - Coal conversion;
  - Extension of district heating;
  - Electrical heating systems and heat pumps;
  - Electricity in the traffic sector;
  - Additive energies.

5. Application of the Findings Presented to Other Countries

If the question were to be raised as to the benefits which other countries in other regions of the world might draw from the German, or rather European, experience and developments of the last few decades, the answer might be as follows:

1. Two aids are available for the rational and economic use of energy reserves. On the one hand, inventiveness, i.e. fantasy and intelligence, on the other, capital, i.e. investment.

2. All energy saving measures need to be optimized (Fig. 23). Falling energy costs generally mean rising capital costs. Every "energy system" needs to find the system's cost minimum no matter whether it is the energy economy of an industrial plant or of an entire national economy. The inherent laws can be transferred, and mathematical models have been developed which, with allowance for the decisive boundary conditions being made, can assist in finding the optimum system organisation.

The Federal Government, state research institutes, universities and industry are prepared to make these existing tools available to other countries.

3. Competition between the individual primary energy forms cannot but serve the purpose of finding the optimum energy mix for the individual application.

In the long term, humanity cannot afford to ignore any usable energy source.

4. Mono-energy systems are a danger to every national economy. The challenge is to find the best possible diversification.

5. Changes and adaptation processes in energy systems take place over long periods of time. All those who have to take and enforce decisions in this field should plan for the long term and follow paths which have been adjudged correct through to the bitter end without regard for the upheavals of day-to-day politics.

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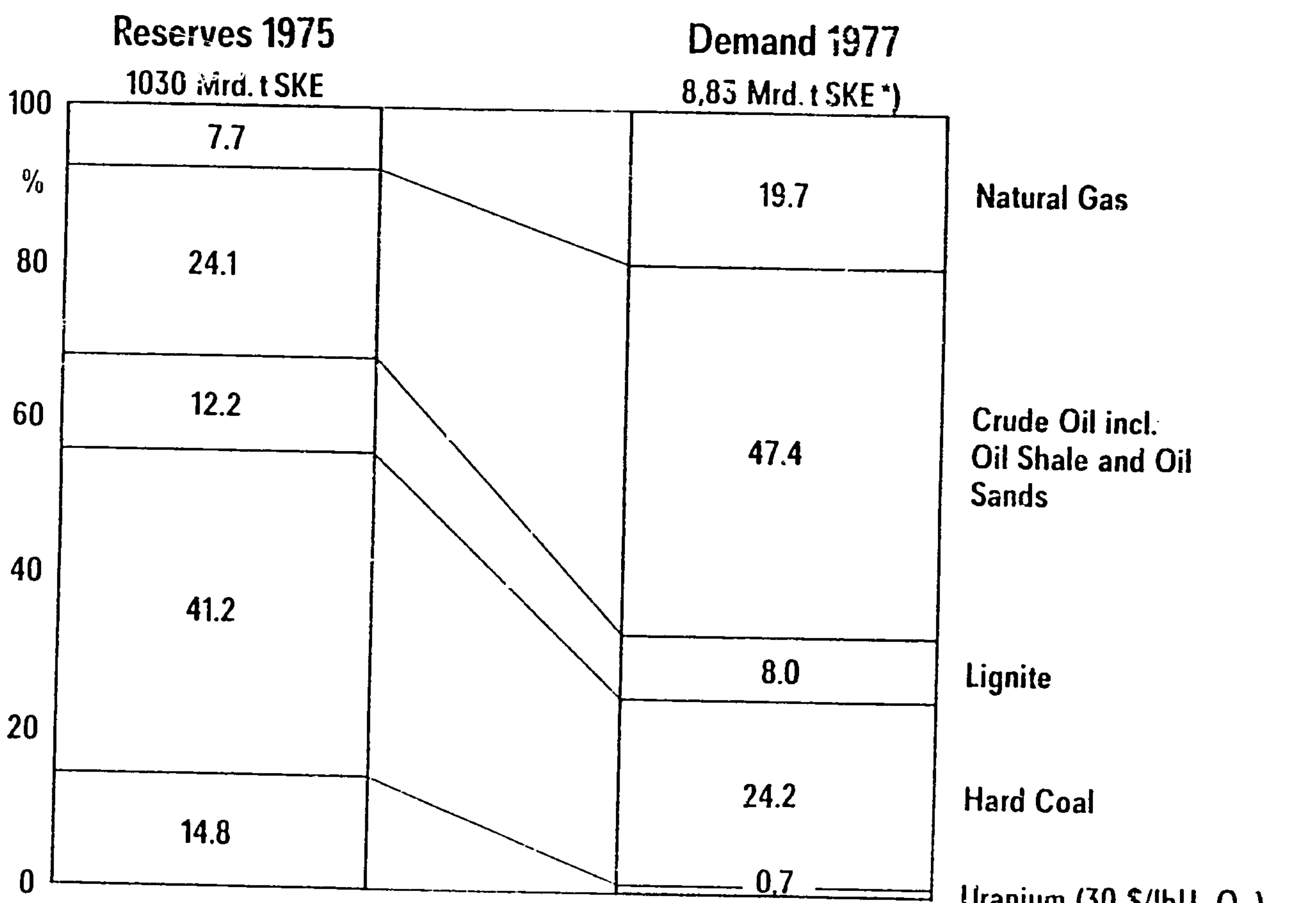
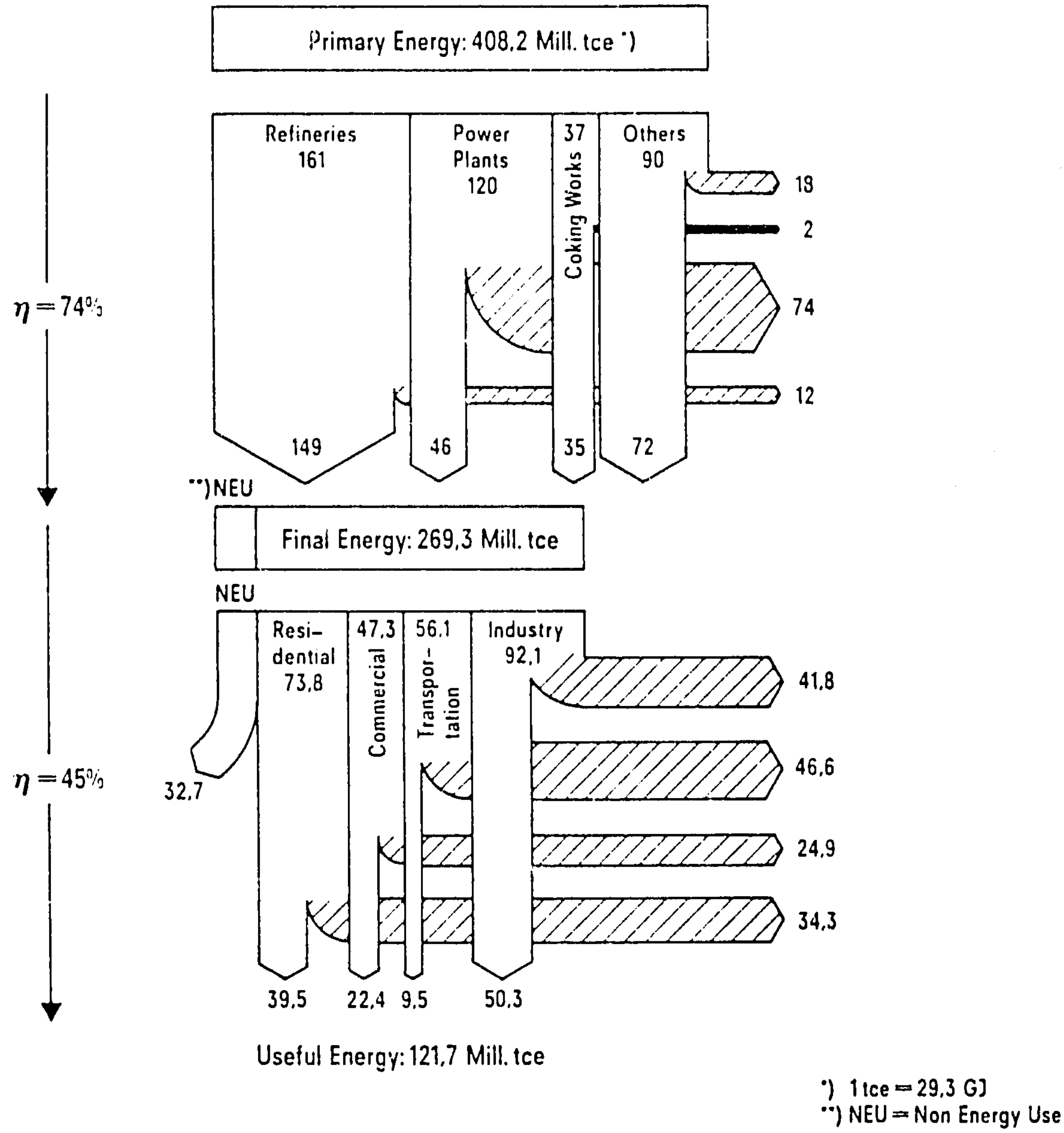


*) 1 Mrd. t SKE = 10^9 Metric Tons Coal Equivalent

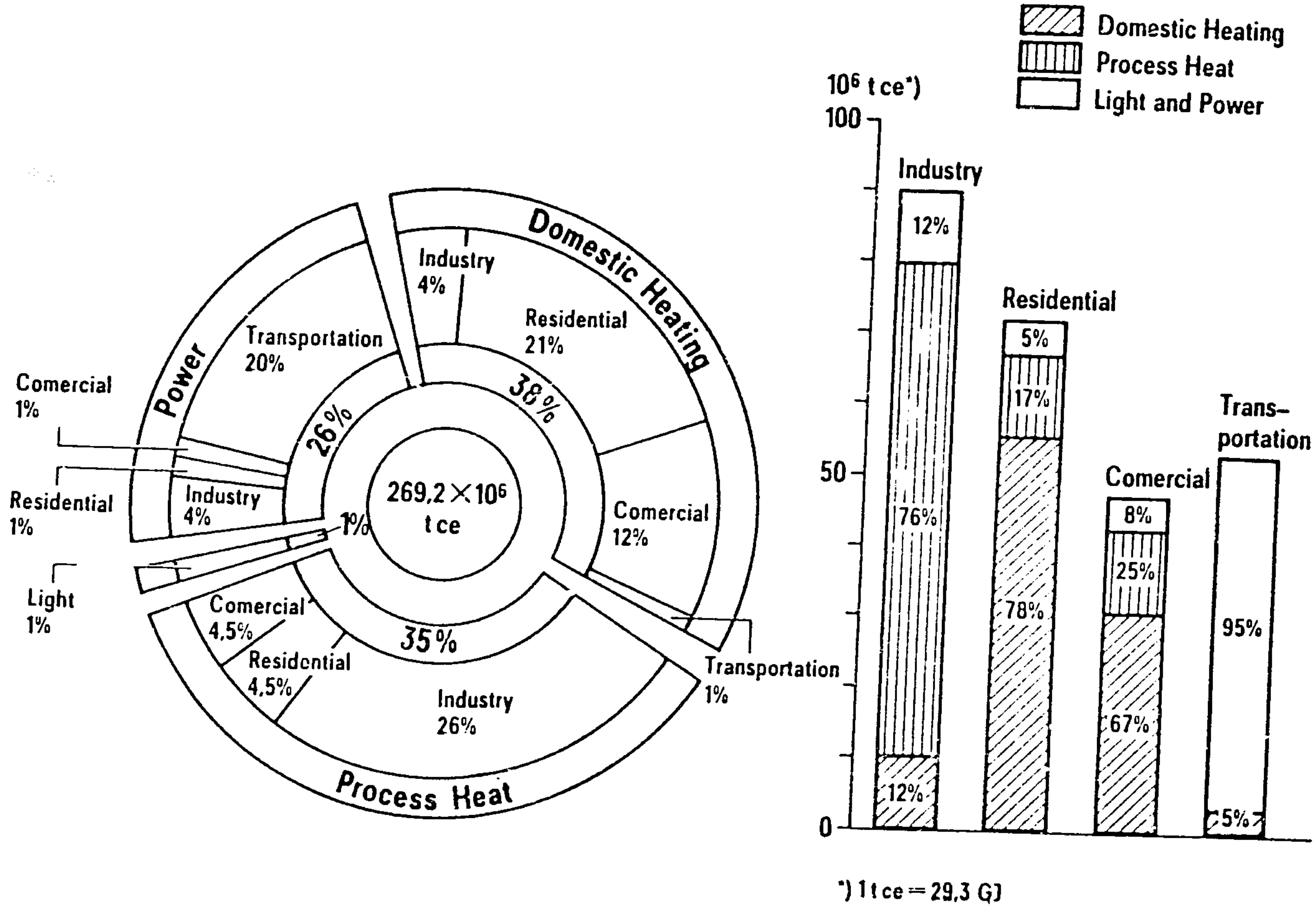
Economically Exploitable World Energy Reserves and Demand [2]

Fig. 1



Energy Flow in the Federal Republic of Germany 1979 [1]

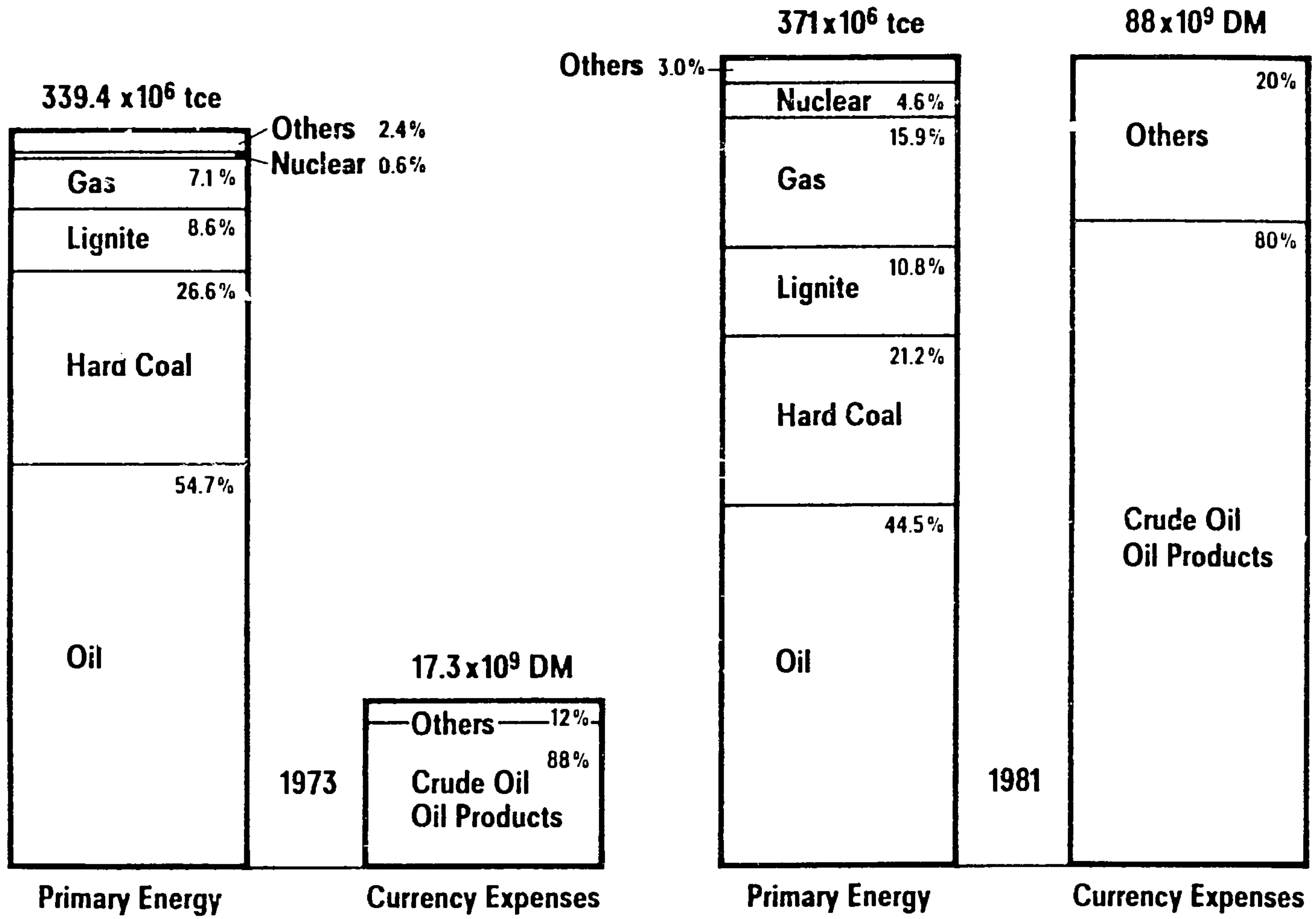
Fig. 2



Break down of final energy into demand sectors and types of energy (Federal Republic of Germany 1979) [6]

Fig. 3

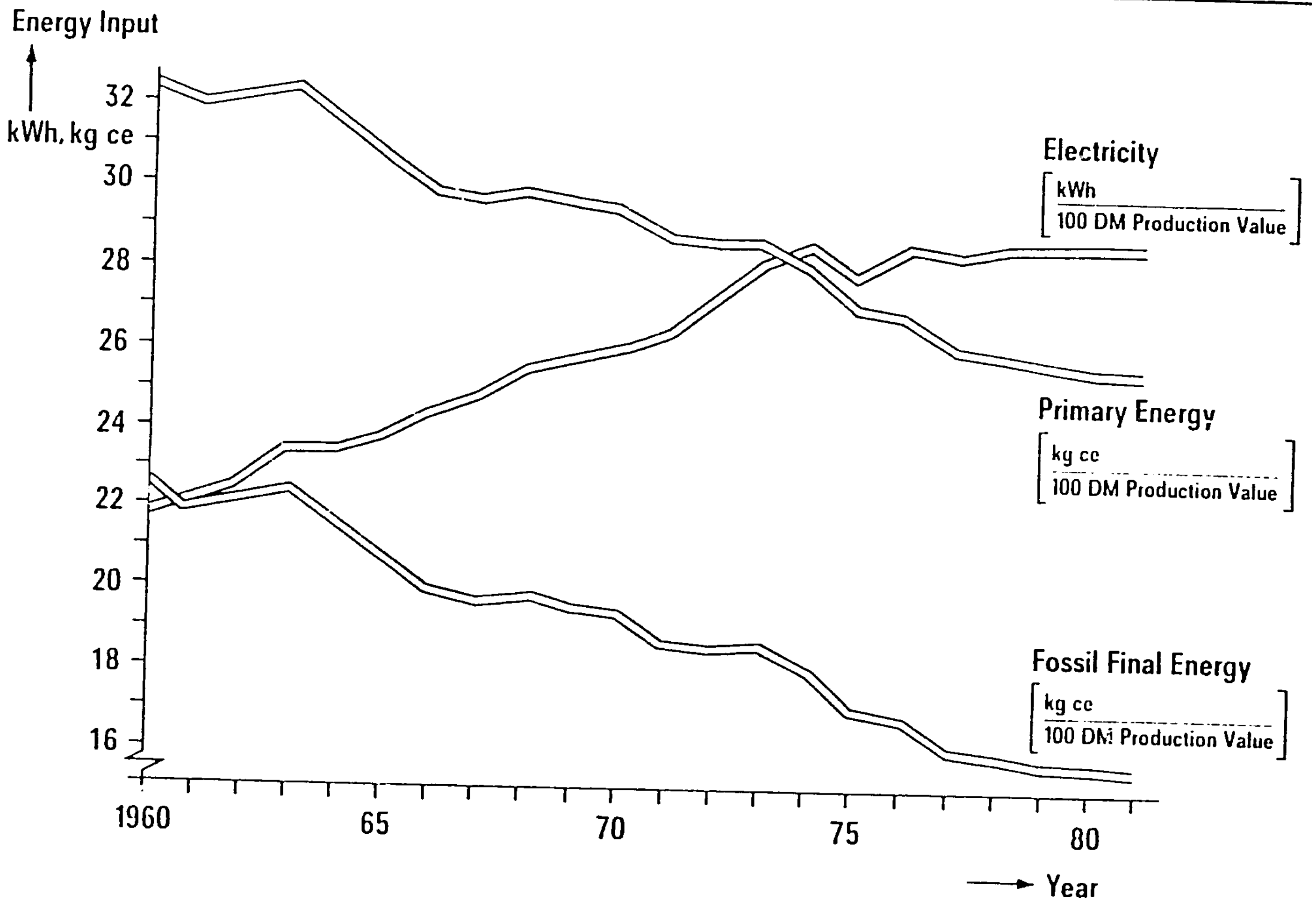
Kraftwerk Union



Primary Energy Demand and Foreign Currency Expenses for Energy (Federal Republic of Germany) [3]

12 292 Ce

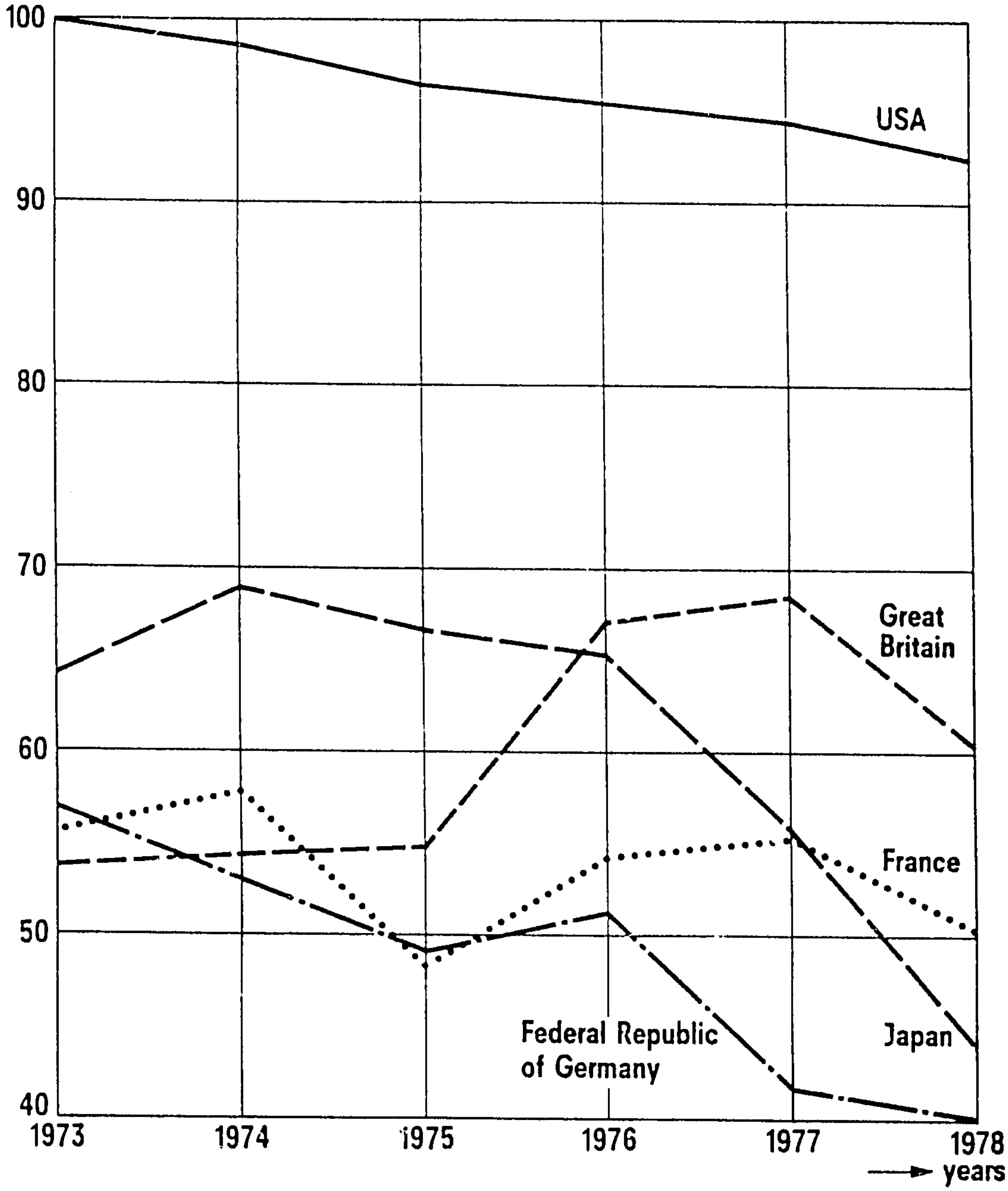
Fig. 4



Specific Energy Use in Industrial Production
(Federal Republic of Germany) [3]

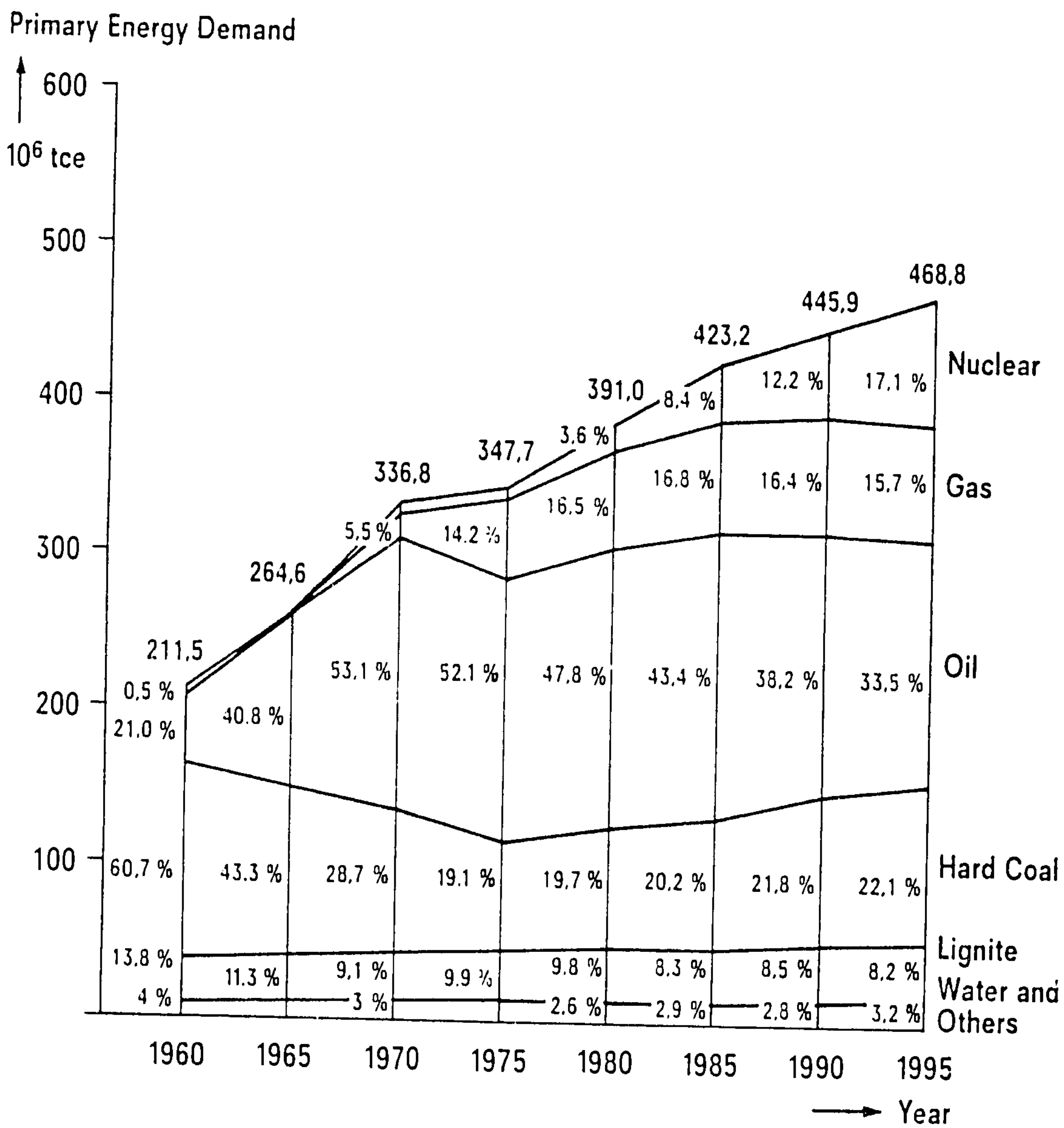
E 82 324 Ce a

Fig. 5



International Comparison of Energy Intensities
(primary energy consumption vs. real gross domestic product) [9]

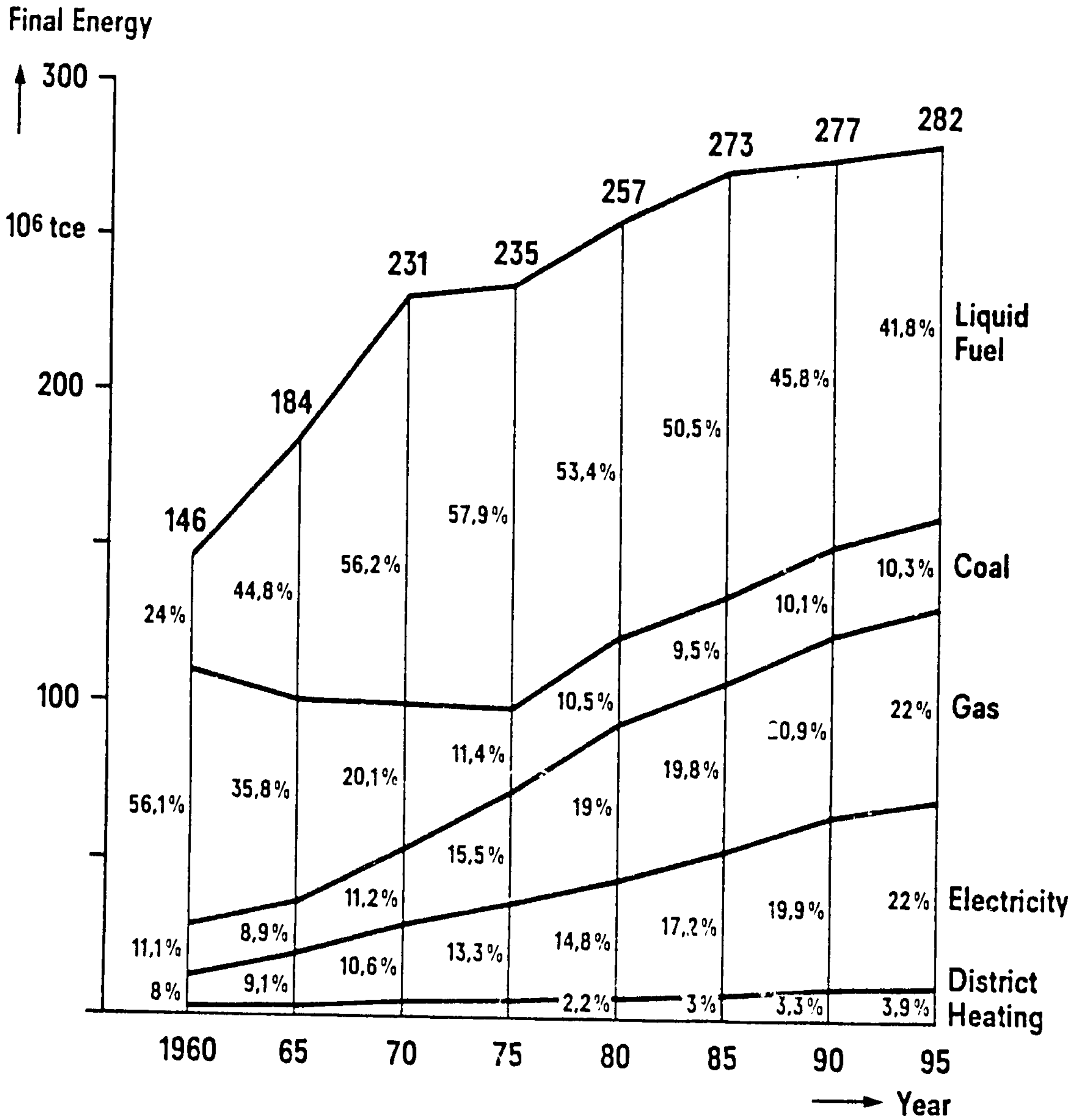
Fig. 6



Primary Energy Demand
(Energy Program, Federal Republic of Germany, 1981) [3]

E 82 033 Ce a

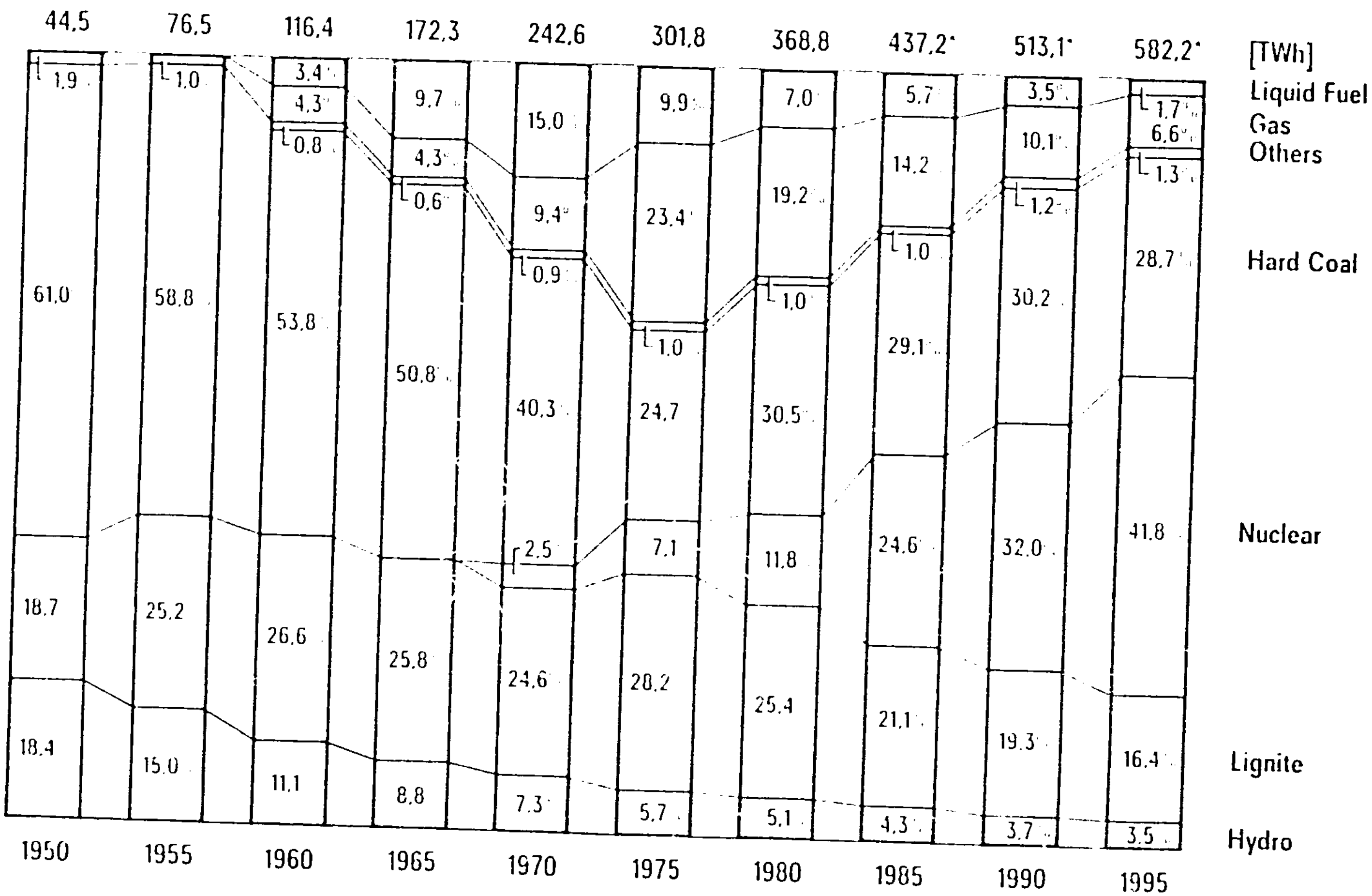
Fig. 7



Final Energy Demand
(Energy Program, Federal Republic of Germany, 1981) [3]

E 82 285 Ce

Fig. 8

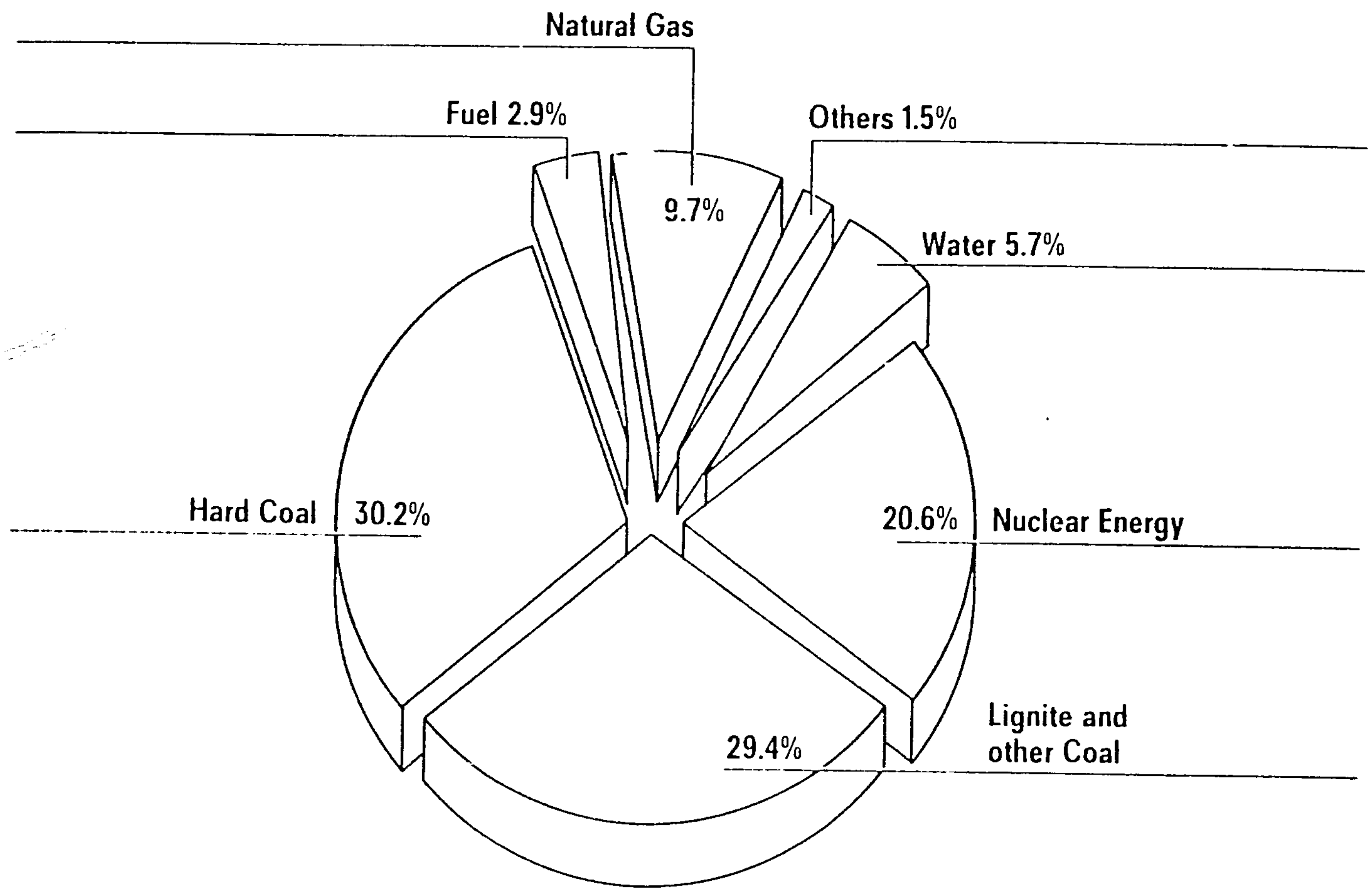


* Energy Program 1981 (medium demand scenario)

Gross Electricity Generation in the Federal Republic of Germany

E 82 646 Ce

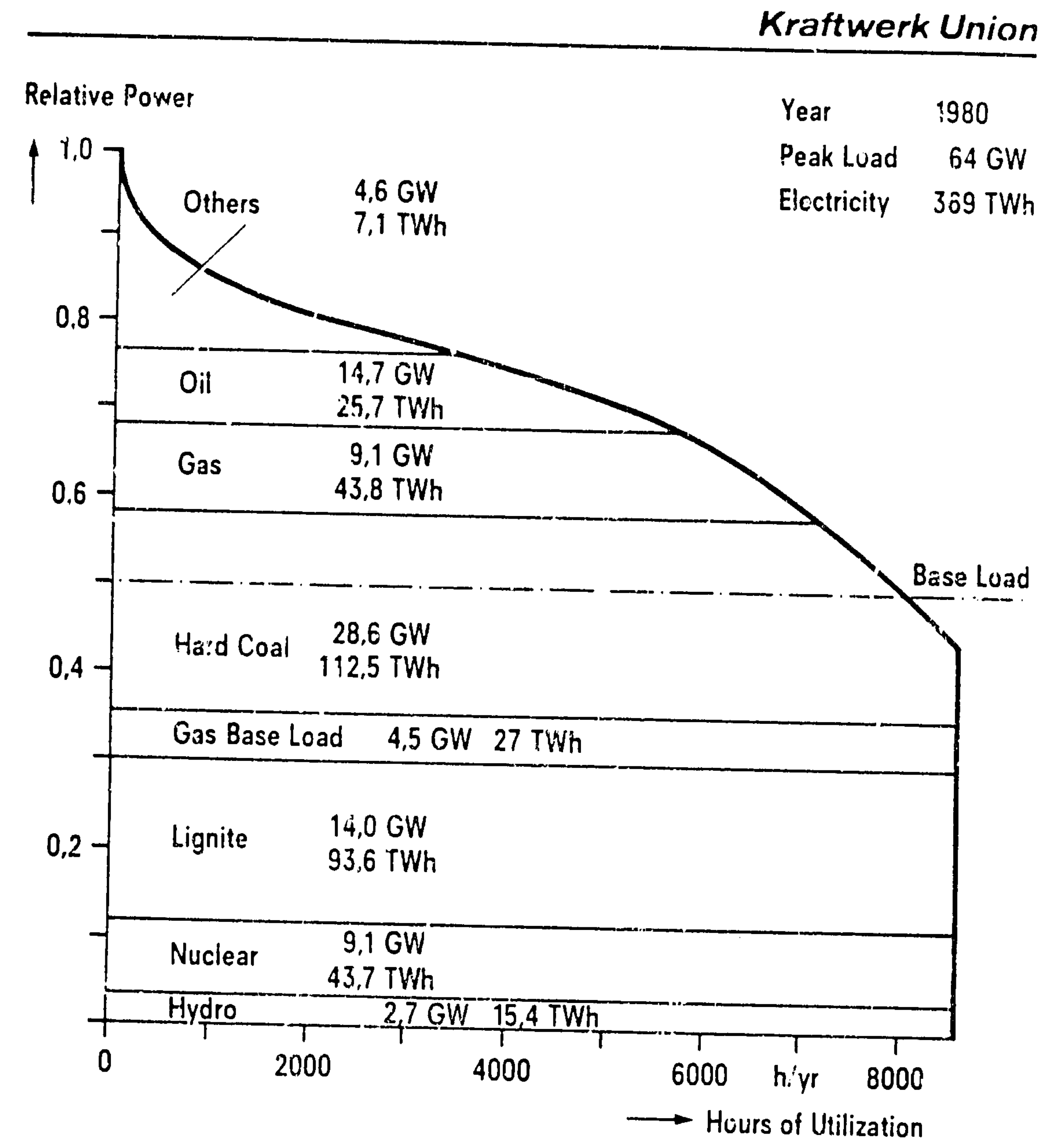
Fig. 9



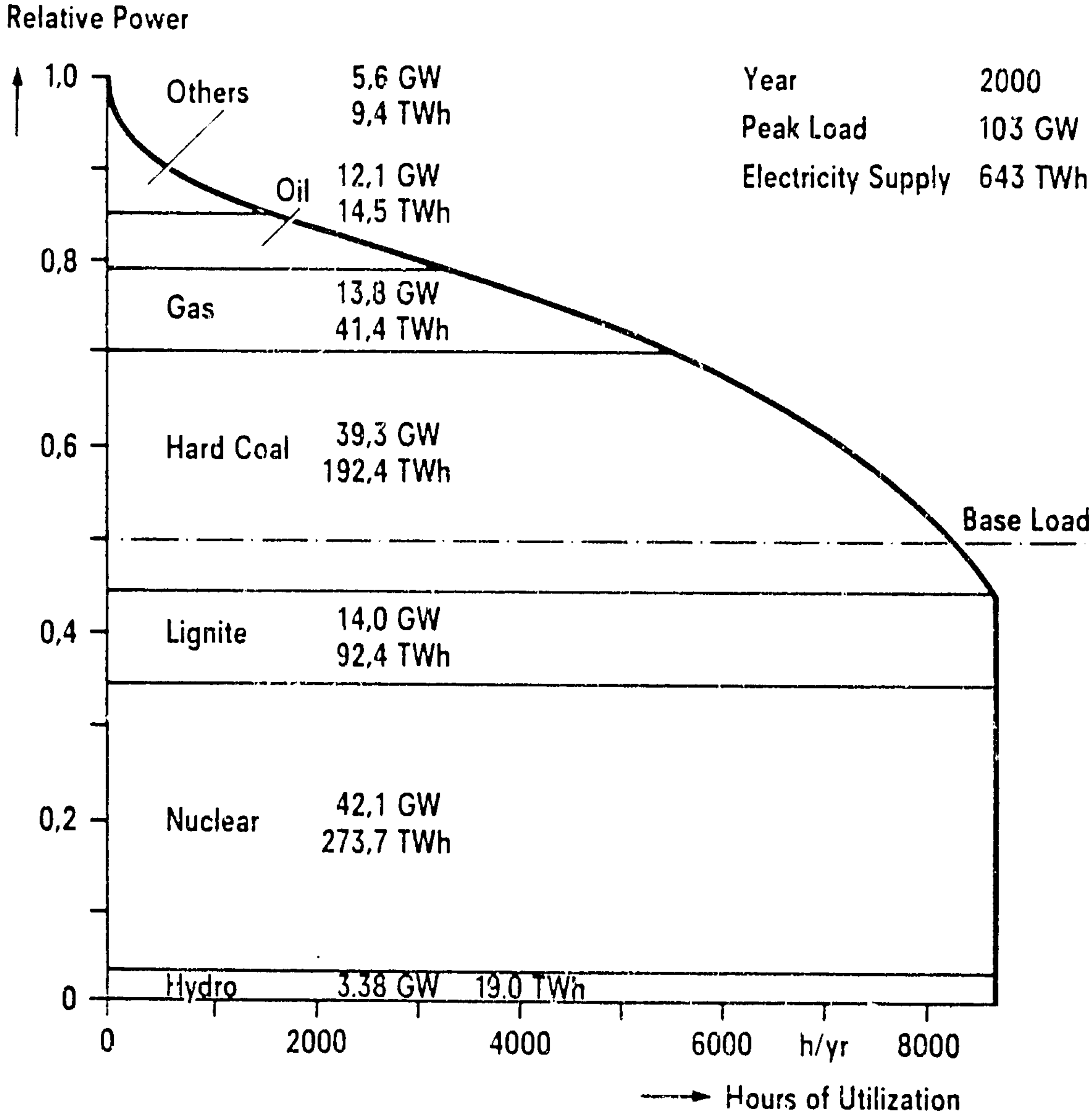
Primary Energies for Public Electricity Generation
Federal Republic of Germany 1982 [4]

Fig. 10

Fig. 11



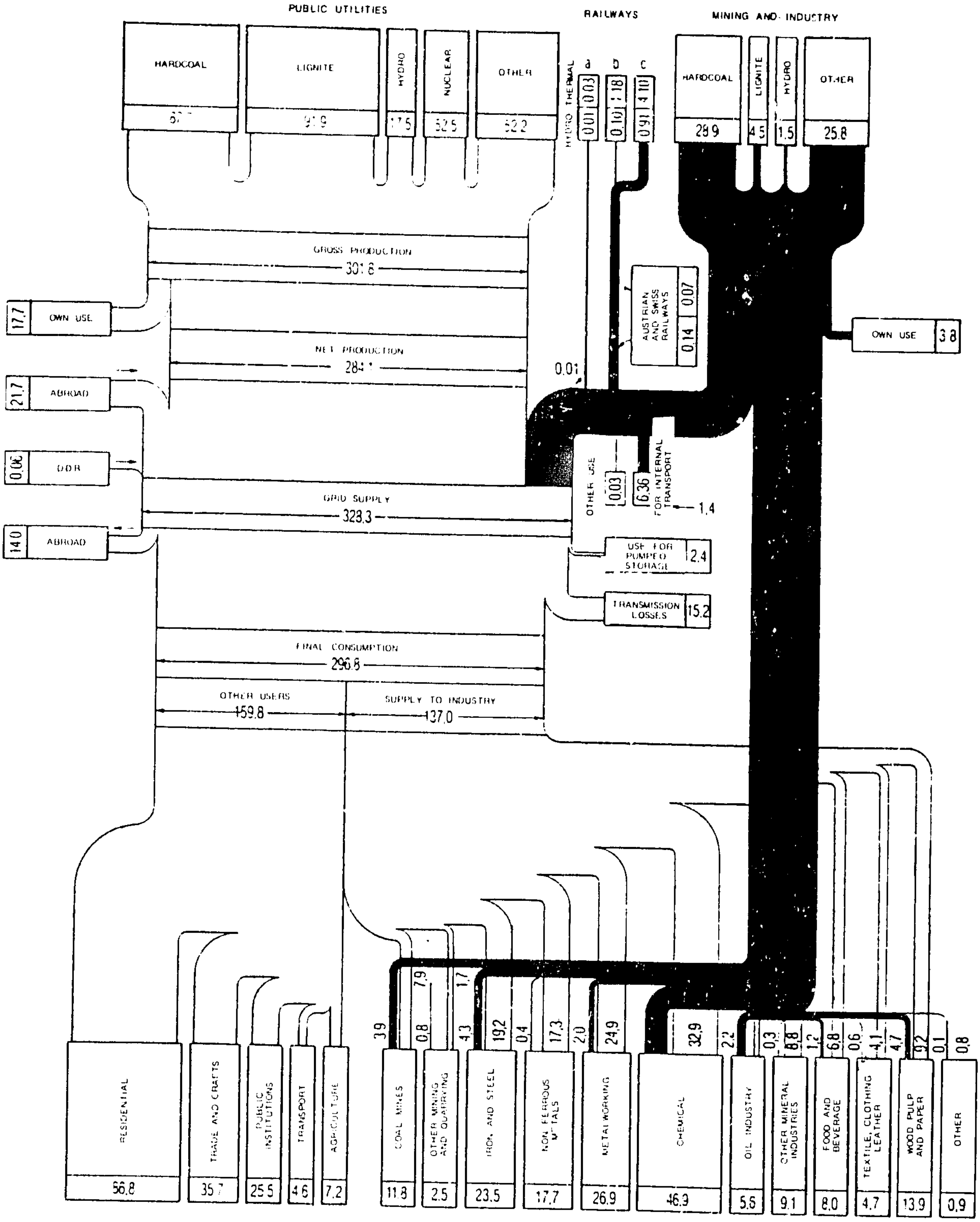
Annual Load Characteristic of Electricity Supply (Federal Republic of Germany) [3]



Annual Load Characteristic of Electricity Supply (Federal Republic of Germany) [3]

E 82 291 Ce

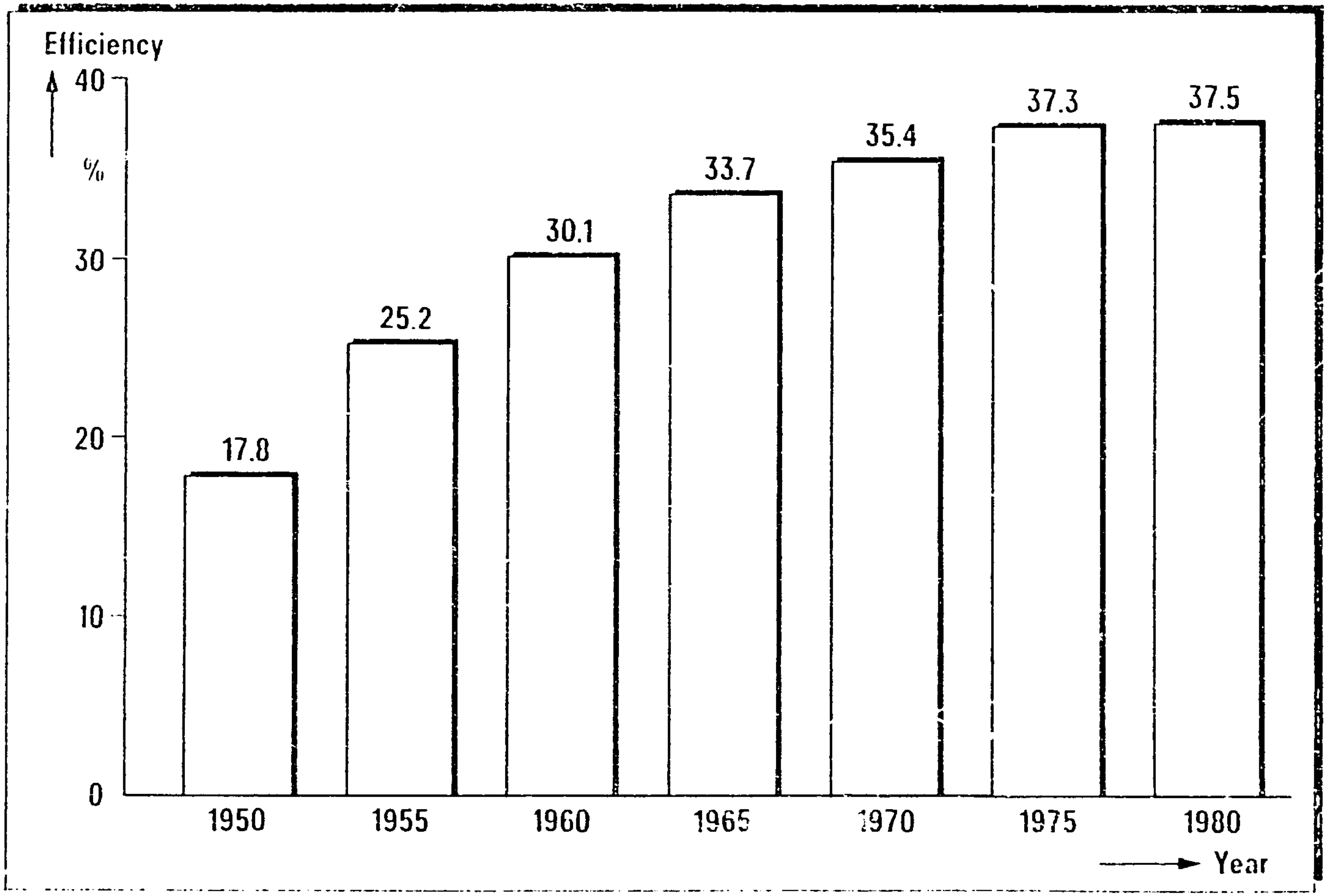
Fig. 12



FLOWCHART FOR ELECTRICITY FOR THE FRG IN 1981 (TWh)

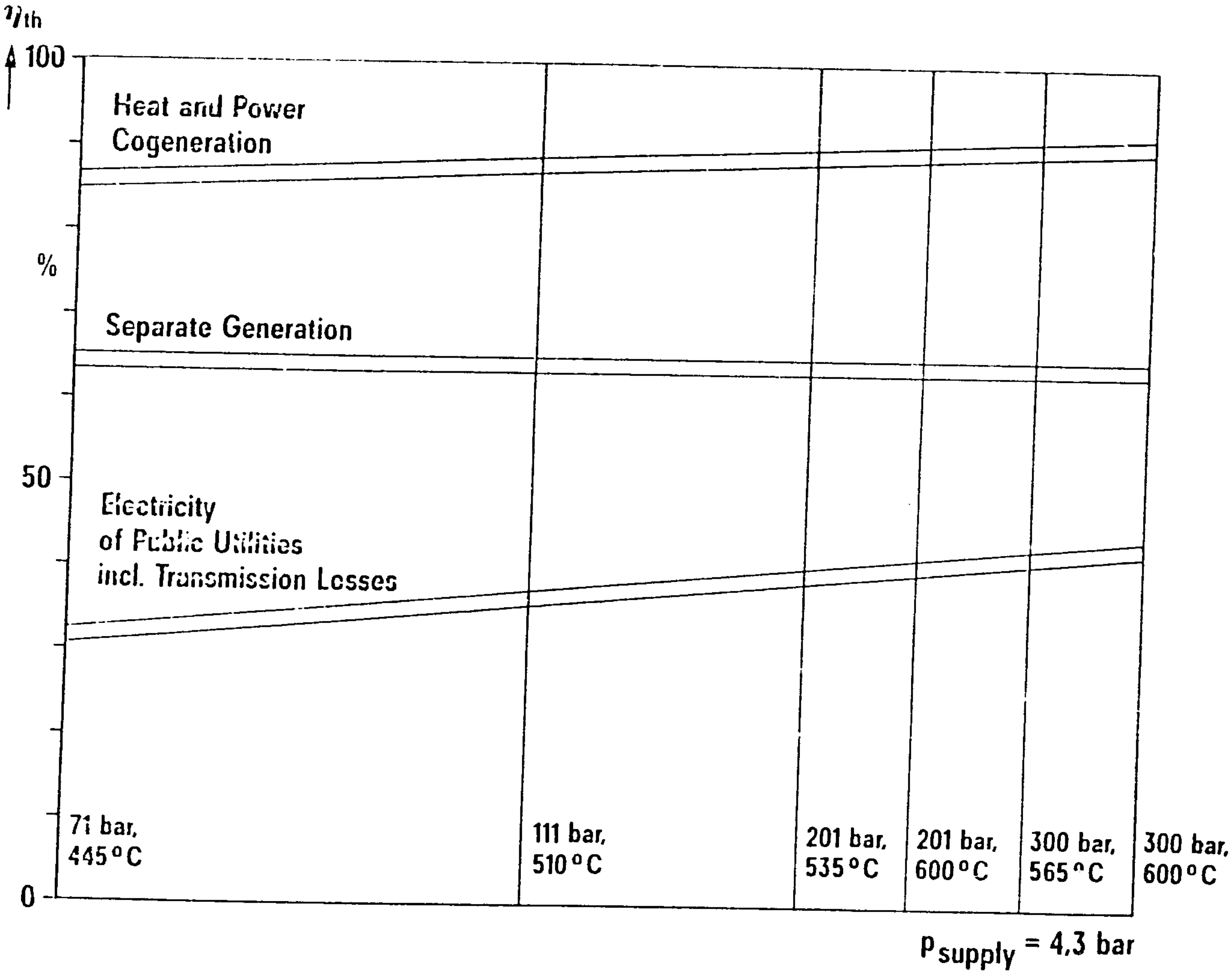
Figure 13

Elektrizitatswirtschaft, Jg. 81 (1982), Heft 21



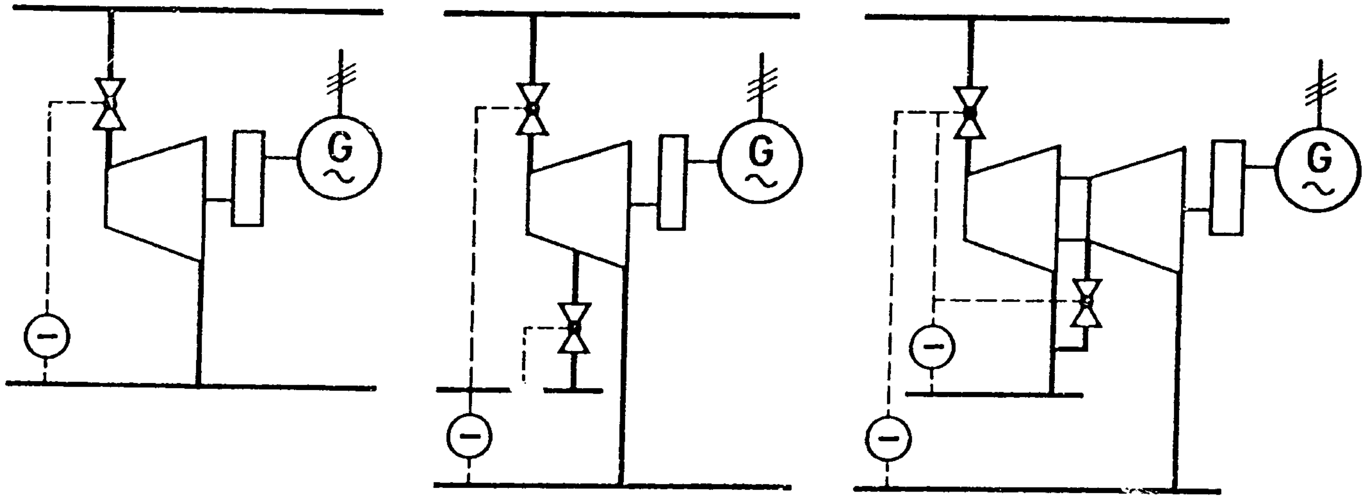
Efficiency of Gross Electricity Production
in the Federal Republic of Germany [7]

Fig. 14



Efficiency (thermal) for Heat and Power Cogeneneration [24]

Fig. 15



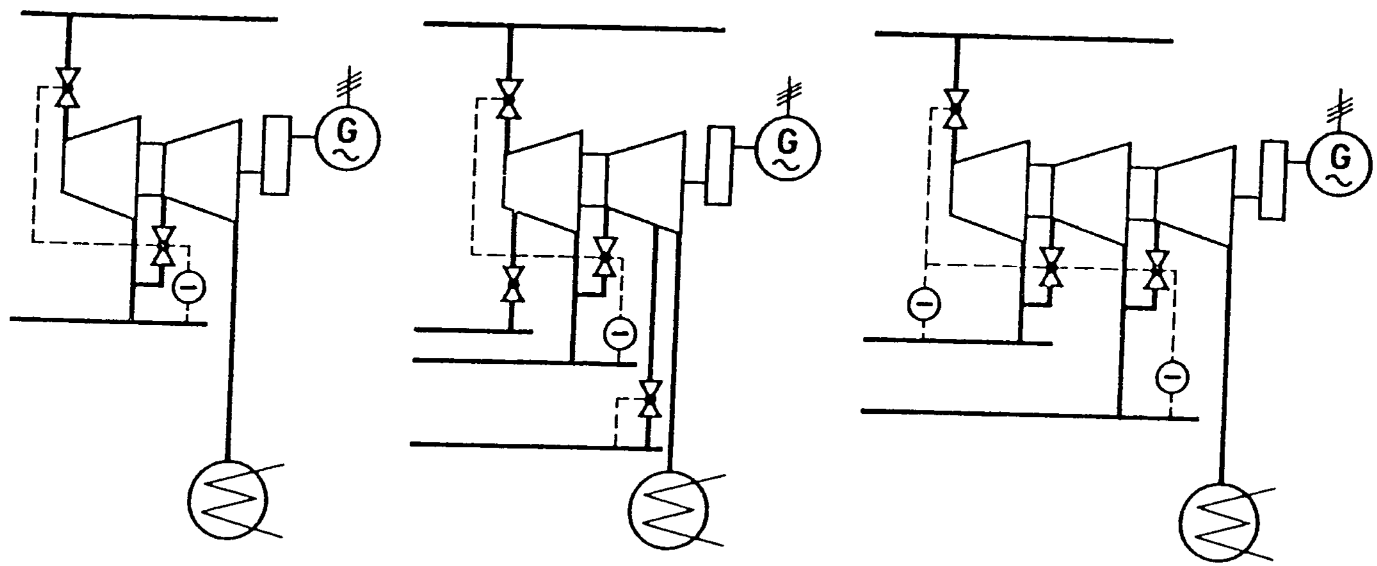
Basic Design

Design with Bleed

Design with Controlled Extraction

Backpressure Turbines for Combined Heat and Power [22]

Fig. 16 a



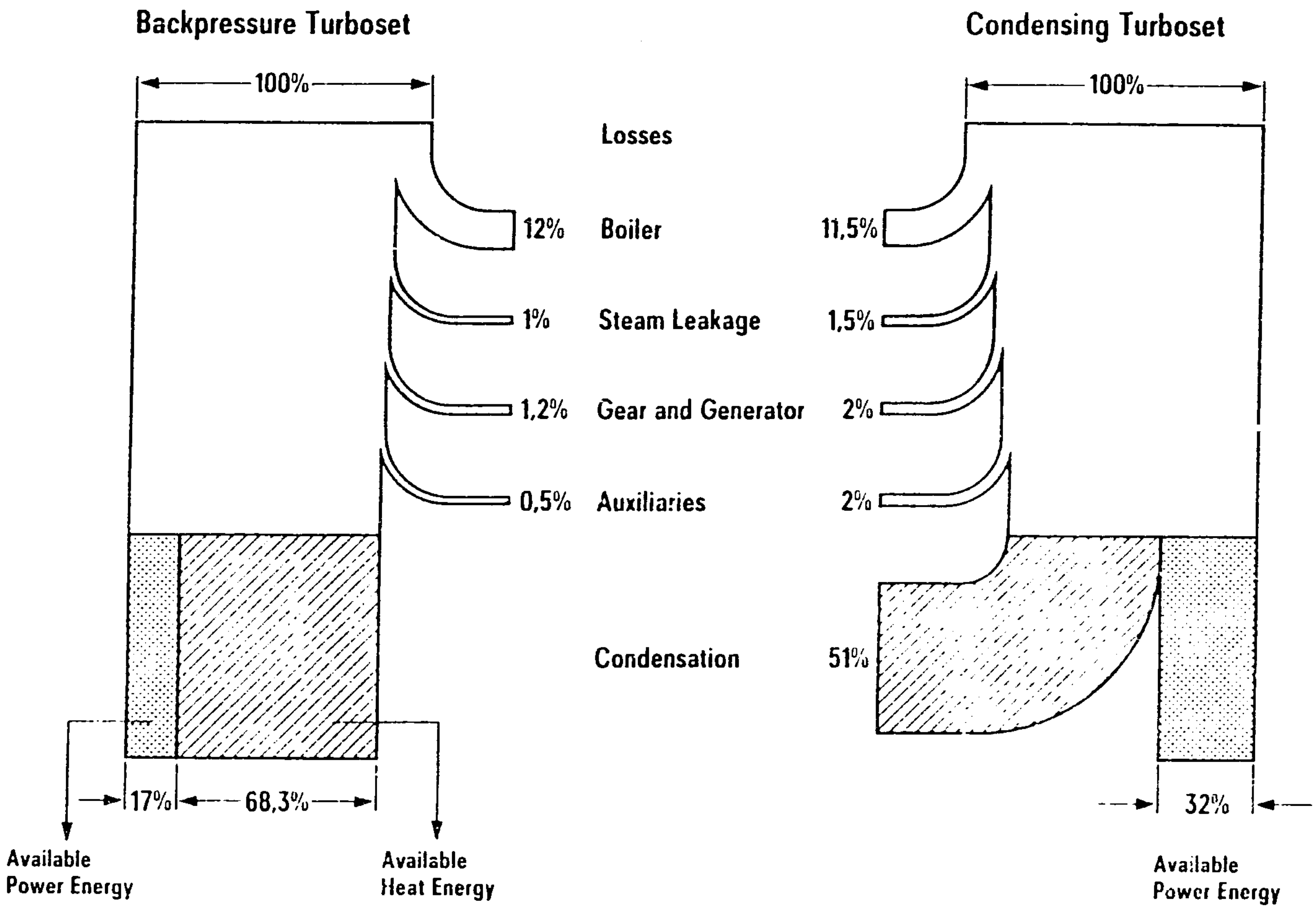
Basic Design

Design with Bleed from HP and LP

Design with Double Controlled Extraction

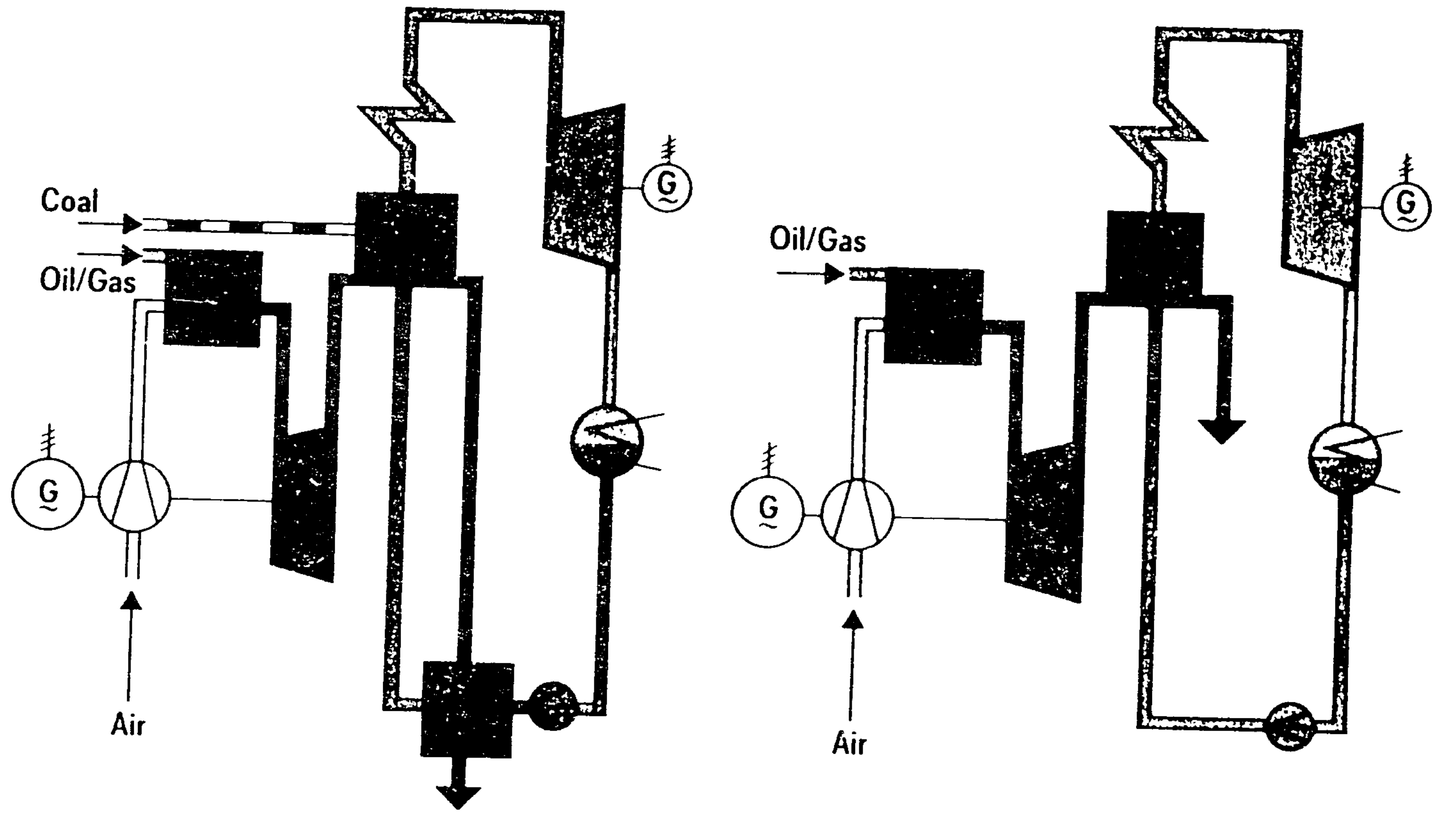
Extraction Condensing Turbines for Combined Heat and Power [22]

Fig. 16 b



Energy Distribution Diagrams
for a Backpressure and a Condensing Turbine Generator Set [22]

Fig. 17



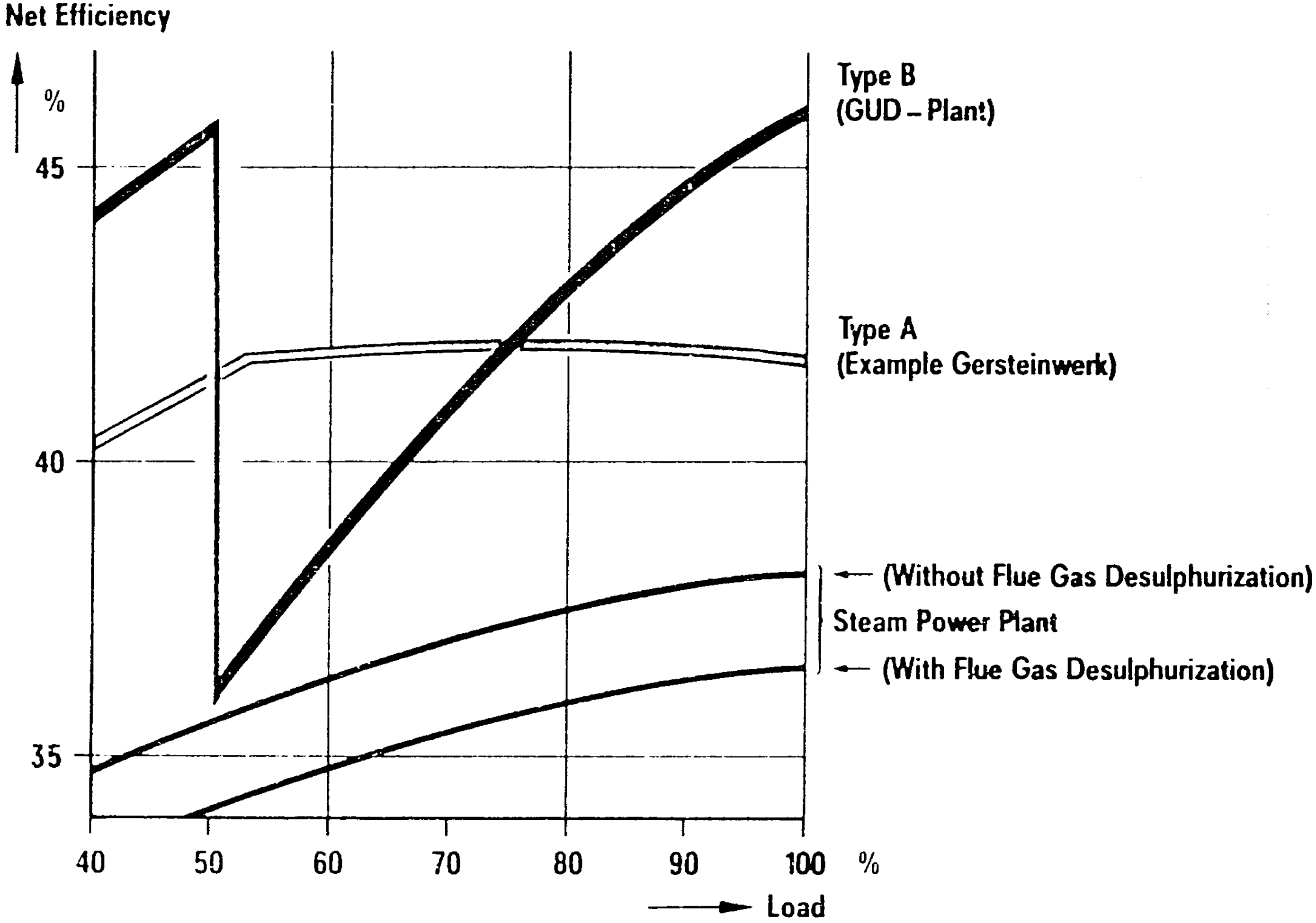
Type A (Example Gersteinwerk)

Type B (GUD – Plant)

Combined Steam and Gas Turbine Cycles of the Conventional Type

E 80 715 Ce

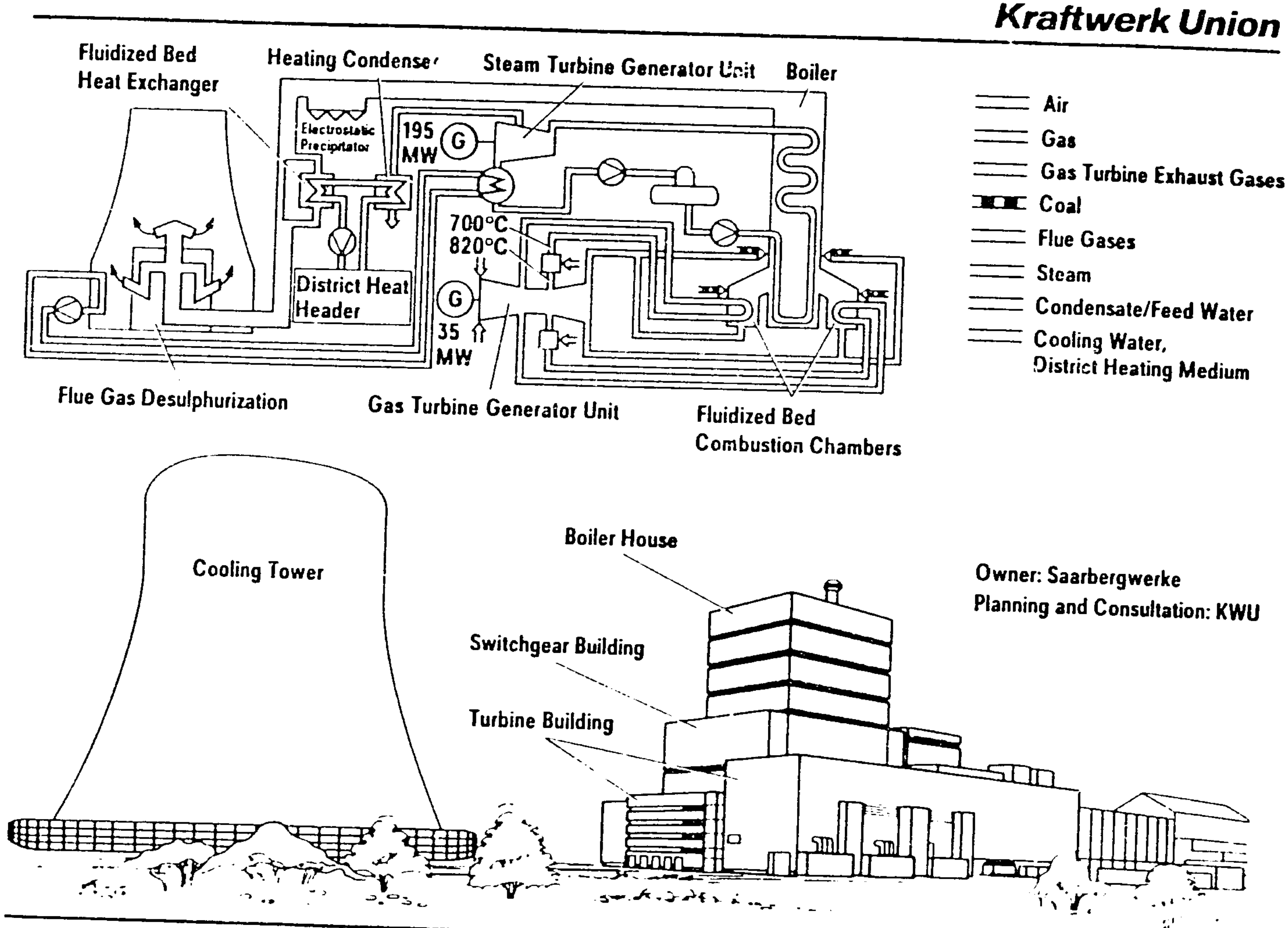
Fig. 18



Combined Cycles of the Conventional Type
Comparison of the Efficiencies

E 80 703 Ce

Fig. 19

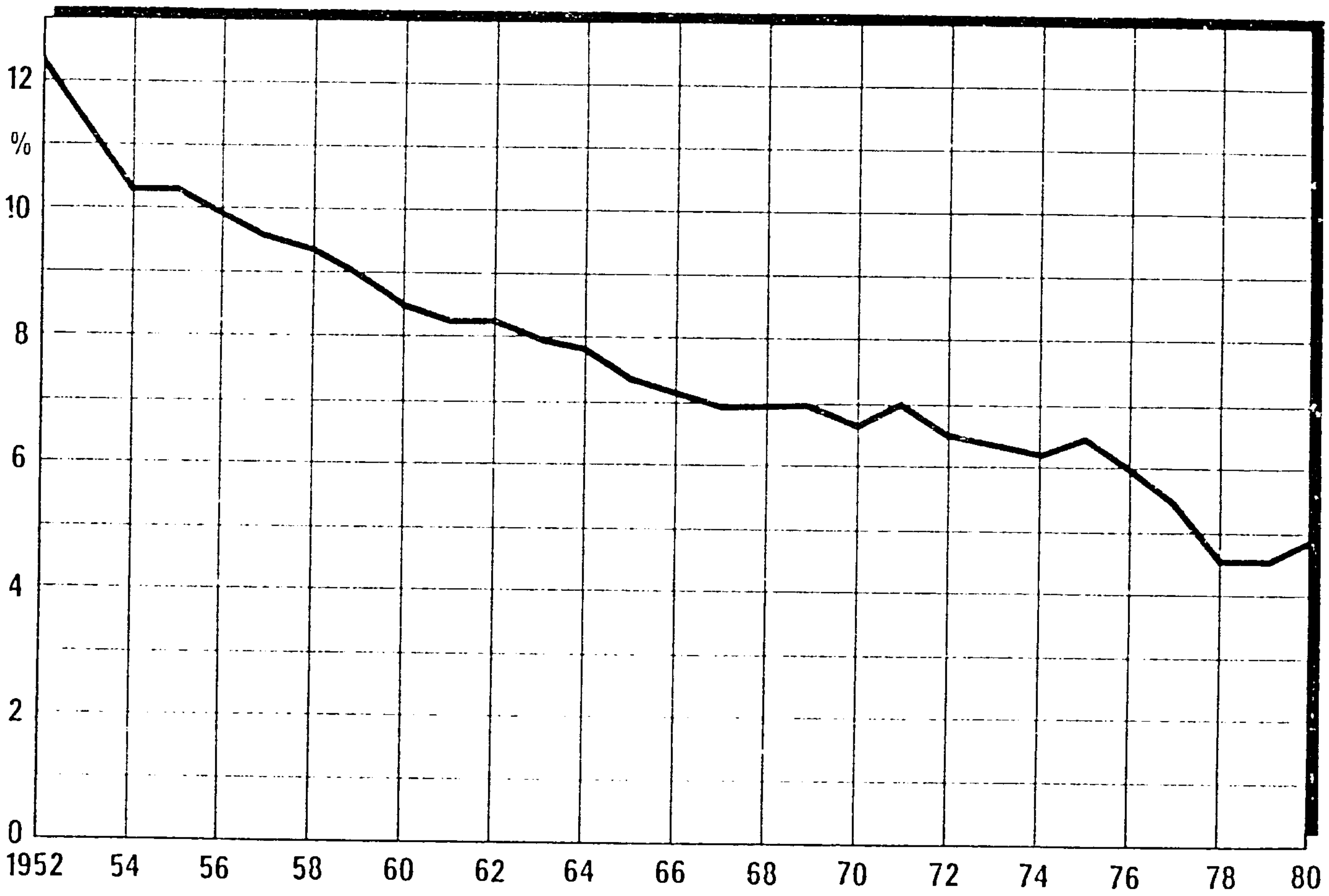


Völklingen Power Plant [3]

79750Ce

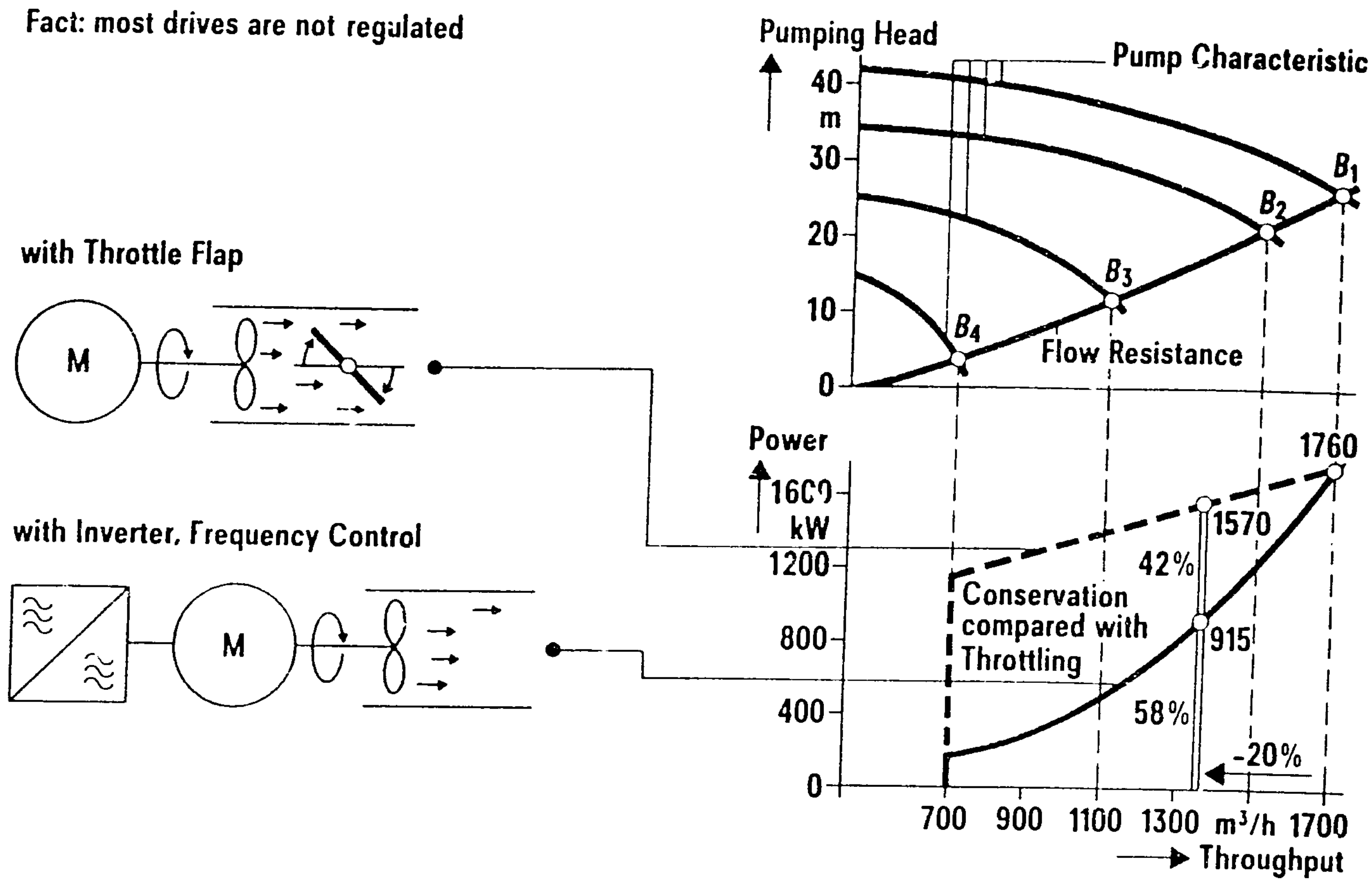
Fig. 20

Kraftwerk Union



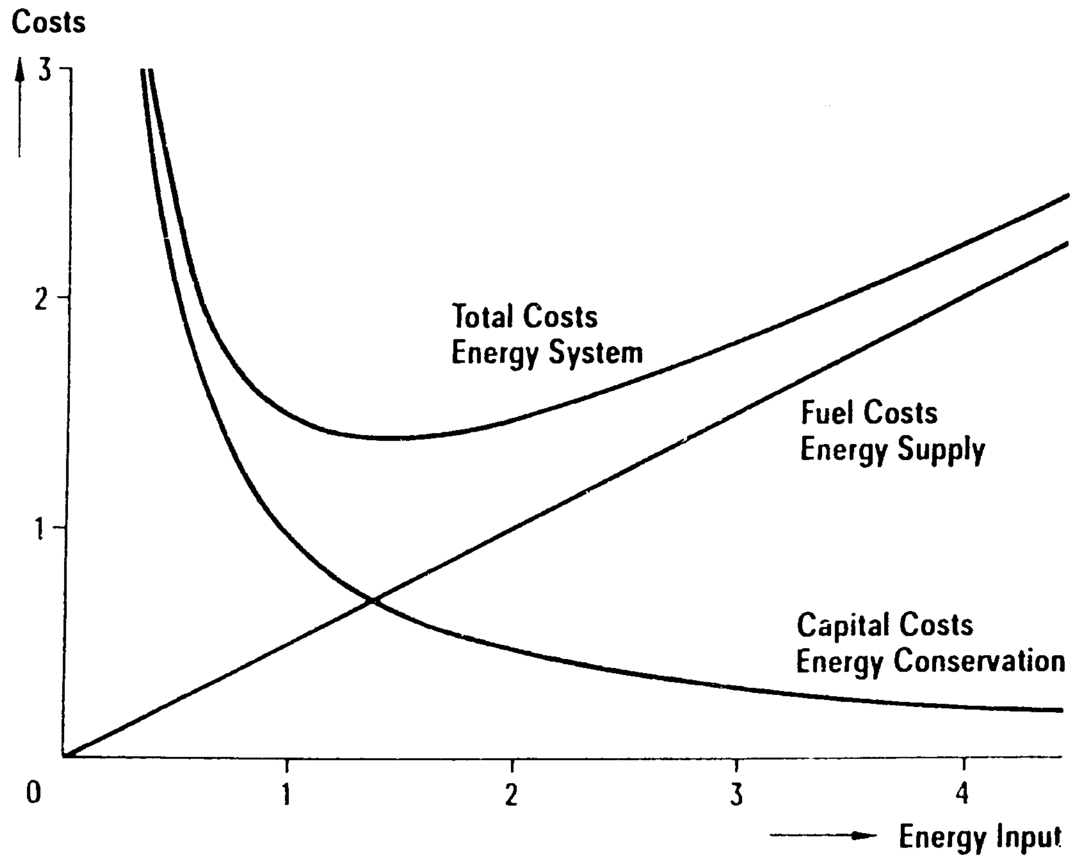
Electricity Distribution Losses
(Federal Republic of Germany) [5]

Fig. 21



Energy Conservation using Frequency Controlled Drives
Example: Throughput Control [8]

Fig. 22



Costs of Energy Service [3]

Fig. 23

: 81 966 e

Rational Use of Energy in Electricity Production - Energy Consumption in Industry: "Synopsis of El Salvador"

Francisco E. Granadino
Executive Director
Hydroelectric Lempa River Executive Commission (CEL)
El Salvador

1. INTRODUCTION

Central America is a region whose natural energy resources are limited to a few sources of primary energy such as organic, hydraulic, geothermal and hydrocarbon resources.

When the word "Energy" is mentioned, it is usually associated with the concept of electricity which is, in reality, the byproduct of a transformation of primary energy; and thus, it is termed secondary energy and utilized as such for human consumption.

El Salvador with an area equivalent to 5% of that of Central America, and a population approximately 25% of the total population of the region, holds a prominent place as a producer of electric power with a combination of hydroelectric, conventional steam, gas turbine and geothermal power plants and a transmission system forming a grid providing a reliable supply of electricity, a very important component in the economic and social development of the country.

The use of electricity was initiated in El Salvador at the beginning of the present century; first, in the residential sector; later, in the commercial sector; and finallv, in the industrial sector. It was produced in small gasoline or diesel plants; as demand increased the alternative of commercial exploitation through small private enterprises was considered as small hydroelectric and thermal plants were built without any thought to demand projections.

2. THE ELECTRIC POWER MARKET

2.1 Institutional Development

The technological development following the Second World War made its impact in El Salvador and brought about industrial development which, added to the population increase and the reduced size of its territory, resulted in demands for electricity which could not be met with the generating means available in the 40's.

The uncontrolled increase in demand, and the inadequacy of the private enterprises to meet it, urged the creation of the Lempa River Executive Hydroelectric Commission (CEL) by legislative decree in 1948 as an Autonomous Public Service Agency to solve the problem of the supply of electricity required by El Salvador's economic and social development.

With the commissioning in June 1954 of the first unit with a capacity of 15 MW for the "5 de Noviembre" Hydroelectric Plant, the first hydropower development by CEL, a new era was initiated in El Salvador in which the existing restrictions to the use of electric power disappeared.

To date CEL has a hydrothermal generating system composed of modern power plants with an installed capacity for 455 MW which meets the demand of much of the national electricity market; this system supplies 90% of the national power demand.

In the year 1981, CEL's organic law was modified by Executive Decree to incorporate the following within its objectives: "to develop, preserve, administer and utilize the energy resources of El Salvador".

Within those objectives, CEL, as the entity responsible for the electric power sector, set the following policies:

- To undertake demand projections and system planning so that the electricity supply will anticipate the demand;

- To utilize in a rational way the existing natural resources for electricity generation;
- To study and promote measures for the rational use of energy by consumers;
- To maintain an on-going programme of research on non-conventional sources of energy;
- to make rational use of the external and internal sources of financing.

2.2 Demand Development

An acute shortage of electricity existed in El Salvador prior to CEL's initial operations in June 1954. By the middle of this century, the installed capacity in El Salvador was 33 MW of which 50% was supplied by private utilities and the other 50% by 200 small plants used in the industrial sector.

With the availability of an unrestricted supply of electricity, the demand increased rapidly in the first years, reaching an historic increase in both power and energy of 10.5% annually, that is, they doubled every 7 years. For the purpose of demand projections, transmission and distribution losses are estimated as 15% of net generation, while the maximum demand of the systems is determined by applying a constant load factor of 0.57 to the net generation projections. Figure I indicates demand and installed capacity for 1954.

2.3 Demand Composition: Percentage-wise

The magnitude of consumption requirements has changed since the start of electricity generation by CEL, with the industrial sector always leading in the demand for energy followed by the residential, commercial and government sectors, in that order.

The following table shows the evolution of the breakdown of demand in percentages:

	1977	1981	
Industrial	45.5%	466.1 Gwh	38.9 %
Residential	26.6	383.1	31.9
Commercial	13.5	165.0	13.8
Government	14.7	185.4	15.4
	100.0	1,199.6	100.0

3. ELECTRICITY GENERATION IN EL SALVADOR

3.1 Hydroelectricity

With the aim of developing, preserving, administering and utilizing the resources capable of electricity generation in El Salvador, CEL policy was oriented to the exploitation of its natural resources; and it was precisely for this reason that the institution was named as an Executive Commission to exploit the hydroelectric potential of the Lempa River for the benefit of the country.

The Lempa River, the largest river in Central America on the Pacific side, has the greatest hydroelectric potential in El Salvador with an international basin of 20,000 square kilometers, half of it in El Salvador.

The exploitation of its hydroelectric potential was planned from the start through a series of cascade projects (see Figure III) for a total of 1,404 MW of power and 4,499 Gwh of mean energy, of which 232 MW of installed capacity and 1,132 Gwh of mean energy have been developed, 17.2% and 26.3% respectively, of its total potential.

The hydroelectric projects in the Lempa River current are as follows:

	TOTAL MW	CURRENT MW	YEAR	Gwh/YEAR
Guajoyo	*15	*15	1963	*54
Zapotillo	120	-	-	422
Paso del Oso	40	-	-	152
Cerron Grande	270	135	1977	515
5 de Noviembre	202	82	1954	762
El Tigre	540	-	-	1,718
San Lorenzo	180	**180	1983	722
San Marcos	52	-	-	208
	1,404 MW	232 MW		4,499

* Cancelled when Zapotillo is in operation

** Lempa River Development: 30.5% of power and 43.1% of energy when San Lorenzo is in operation.

Most of the rivers in El Salvador have small volumens with flows of less than one cubic meter during the rainy season and no flow at all during the dry seson. The larger rivers are a source of additional hydroelectric potential for the Lempa River.

The available hydroelectric potential is as follows:

Lempa River	1,404 MW
Rivers with permanent flow	60 MW
Lakes (Ilopango, Olomega)	45 MW
Rainy season rivers	43 MW
	1,552 MW

3.2 Thermoelectricity

In order to meet the market's increasing demand, conventional thermal plants were incorporated into the planning of CEL's electrical systems to back-up hydropower generation due to the irregular hydrology of the Lempa River basin, thus reaching 128.2 KW as follows:

Steam Power Plant	63 MW	1966 - 1969
Gas Turbine Power Plant	65.2 MW	1972 - 1973

The addition of the thermal plants to the system was totally justified then as the best technical and economic alternative.

3.3 Geothermoelectricity

Geothermal investigations were initiated in El Salvador in 1964 to establish the existence of geothermal resources suitable for electrical generation.

This research, intensified in the 70's, identified the geothermal field of Ahuachapan with an estimated capacity of 100 MW.

At the same time, investigations in other areas of the country, where endogenous manifestations were visible, were carried out identifying the geothermal fields of Berlin, San Vicente and Chinameca in the eastern section of the country and Chipilapa close to the Ahuachapan field.

The investigations were successful, a geothermal plant with an installed capacity of 95 MW was put into operation in Ahuachapan, while establishing the feasibility of another plant at Berlin and possibilities of tapping this natural resource at Chipilapa, San Vincente and Berlin.

Available data estimates indicate the capacity of geothermal electric power generation as follows:

Ahuachapan Plant	95 MW	(in operaion since 1975)
Berlin Plant	55	
Chipilapa Plant	55	
San Vicente Plant	55	
Chinameca Plant	35	
	295 MW	

The installed capacity of the electricity generating system has increased in an orderly manner from the year 1954 to date, from 30 MW to 455.2 MW in 1982 with the following breakdown:

Hydroelectricity	323	MW	51.0%
Geothermoelectricity	95	MW	20.9%
Thermoelectricity	128.2	MW	28.1%
	455.2	MW	100.0%

The historic trend of the installed capacity is shown in Figure III, with a large hydroelectric component since the beginning. Recently, from 1975 on, with the geothermal component the installed capacity based on natural resources in 72% of the total. When the San Lorenzo Hydroelectric Plant goes on stream this year the percentage of installed capacity based on natural resources will be 80%, as follows:

	1984		
Hydroelectricity	412	MW	64.9%
Geothermoelectricity	95	MW	15.0%
Thermoelectricity	128.2	MW	20.1%
	635.2	MW	100.0%

4. ENERGY CONSUMPTION IN INDUSTRY

The industrial sector is predominant in the consumption of electricity with 47% of the total demand; nevertheless due to the socio-economic crisis in the country, its participation has decreased to 39%.

Three forms of energy participate in the workings of the industrial sector: oil, bagasse and electricity. Of the three, the one with the greatest participation is oil, with 47%; followed by sugar cane bagasse, with 37.5% and then electricity with 15.5%.

In 1981 the consumption of energy in the industrial sector, by products was as follows:

	Total	%
Electricity	499	15.5
Fuel Oil	1,058	36.6
Diesel Oil	242	8.4
Bagasse	1,079	37.3
Others (Oil-products)	63	2.2
	2,891	100.0

The high percentage of the oil products is clearly shown with its 47.2% of the total energy consumption in industry. This percentage clearly indicates the need for rationalizing their use. They are foreign imports with a heavy impact on the balance of payments of the country.

Electricity participation is 15.5% and there is a distinct upward trend due to the substitution of diesel generation by electricity. Except for small quantities used in station service at the refinery, diesel is burned to produce steam for heating processes. The relative increase in electricity suggests that the new industries are of the electricity-intensive type, such as textiles, shoe manufacturing, etc. in lieu of the steam-intensive industries such as sugar refineries.

The rational use of energy is evident in the industrial sector; studies are required to determine the efficiency of energy consumption in the different industries, possible substitution in one form of energy by another and the cost of modifications or substitutions in the industrial processes in order to obtain better efficiences.

There is no definite policy in El Salvador regarding the steps to be taken by the public and private sectors with respect to the rational use of energy in the industrial sector although there are plans to implement audits.

Within the programme to strengthen energy planning capacity, sponsored by the Inter American Development Bank, CEL will undertake a study in the "Planning of Energy Conservation and Energy Audits". The private sector, with the assistance of the Central American Institute of Research and Industrial Technology (ICAITI), will do a series of audits in a great many.

The structure of energy consumption for the year 1982 is shown in Figure IV.

5. THE ENERGY PICTURE

Within the reality that we live in we must state as best we can the energy features of our universe and, in this context, fix the horizons we are intending to reach.

In any case it is necessary to know the historical behaviour of the energy sector so that we might derive a diagnosis and, ultimately, put forward autonomous and non-autonomous projections in accordance with historical antecedents and socio-economic policies of national benefit.

5.1 Demand Situtation

From the historical energy balances it was determined that the energy sector had uniform growth for the period 1970-1979 (with a rate of approximately 5%), with a marked decline for the periods 1973-1974 and 1978-1979, the first due to the world energy crisis and the second to the socio-political situation of the country.

The 1982 energy consumption in El Salvador was as follows:

Sector	%
Industrial	16.5
Residential and Commercial	67.7
Transportation	14.2
Government	0.9
Others	0.7
	100.0

The above consumption was met by the following secondary energy sources:

Source	1979	1982
Electricity	5.0%	5.4%
Oil Products	29.0%	24.2%
Woods	59.0%	64.8%
Bagasse	6.8%	5.5%
Others	0.2%	0.1%
	100.0%	100.0%

Percentage-wise, the composition of energy consumption and energy supply for the period 1970-1978 is similar to that of 1979. It is important to point out the large participation of the residential and commercial sector due to the incidence of the use of firewood for domestic consumption as well as the transportation sector whose overall 14.2% figure includes 59% of the consumption of oil products.

Among the sources of energy, wood contributes massively with 64.8%, followed in magnitude by oil products with 24.2%.

5.2 Supply Situation

At primary energy levels we must know what sources of energy we depend on and we must quantify the availability of same.

Considering energy imports, in 1982 oil was the traditional source that supplied our market in its totality in the transportation sector; 42% in the industrial sector; and 3.2% in the residential and commercial sector.

The availability of oil is quite assured for the time being due to the agreement with Mexico and Venezuela; nevertheless, it is convenient to investigate the possibilities of coal supplies and the eventual use of thermo-nuclear energy.

The natural sources of primary energy are: organic resources which account for 91.2% in the residential and commercial sector and 45.5% in the industrial sector; and the hydro and geothermal resources with a 5.0% incidence in the industrial, residential and commercial and government sectors because of the use of electricity.

It is also important to establish how many inhabitants depend on each source in orde_ to know the priorities and/or implications of the energy policies.

The approximate figures of the beneficiaries of the different forms of energy have been determined as follows:

Electricity	300,000 customers
Oil Products	137,000 vehicles
Wood	3,3000,000 users

The tremendous impact of the use of wood in the energy sector is clearly shown.

5.3 Energy Planning

Energy planning is nothing more than the sequence of actions that are initiated with a view to understanding the energy sector through the historical energy balances followed by a diagnosis of the situations so that the autonomous and non-autonomous hypotheses can be established for the development plans.

Energy balances are used in this process as tools to guide the planning processes.

Energy planning incorporates within its elements the diagnosis of the sector which includes an analysis of the absolute tendencies and an historical analysis of structures; the evolution of the principal economic and social variables as related to energy and the trends shown by macroeconomic indicators. Energy demand is also projected by sectors, products and globally.

5.4 Net Energy Consumption Structure - 1982

%	Secondary Energy	T. Cal.	Sectors	%	
5.4	Electricity	1,119.6	Industrial	38.0	2.06
			Residential	30.7	1.67
			Commercial	13.4	0.73
			Government	17.9	0.97
				100.0	
24.2	Oil Products	4,970.8	Industrial	28.6	6.93
			Residential & Commercial	9.0	2.17
			Transportation	58.8	14.22
			Non-identified	0.8	0.18
			Non-energy	2.3	0.56
			Government	0.5	0.12
				100.0	
64.8	Wood	13,324.6	Industrial	2.7	1.75
			Residential	97.3	63.04
				100.0	
5.5	Organic Material	1,130.5	Industrial	100.0	5.50
0.1	Others: Charcoal & Coke	20.0	Industrial	29.5	0.03
			Residential	70.5	0.07
				100.0	
100.0		20,565.5			100.0

6. THE ENERGY PROBLEM IN EL SALVADOR

6.1 The Energy Picture

The Salvadore society faces the energy problem through three types of energy, each one with its own impact:

Oil products, in the context of national energy, problems are characterized by a high degree of oreing dependence, high costs and outflow of foreign exchange. Without doubt they are a form of energy that we will depend on in the short and medium terms but alternatives must be found to substitute them. This form of energy has a great impact on national economy and substantially affects the transportation and industrial sectors.

Wood is an energy product that affects a very large proportion of the inhabitants, in particular the low-income, rural domestic sector for which wood is the only source of energy. Wood is a form of energy used traditionally and incorporated massively into national energy problems with social implications as well as ecological impact due to the deforestation effect.

Electricity is another of the types used in El Salvador with the characteristic that it is a desirable form of energy that can be produced by local renewable natural resources or by oil products. Electricity is one energy product that supports the economic development of the country in spite of its small role in the energy sector but it is an indicator of the way in which the economy of the country develops.

Now that the energy supply problem has been laid out in terms of the above three types of energy, the question arises: what can we do?

6.2 Formulation of Energy Policies

The problematic situation facing the energy sector due to limitations for the supply of energy has a common denominator: efficient use.

The actions to be taken in coping with this problem can be summarized as follows:

As for oil products, we must increase their efficient use and seek to substitute them by other sources of renewable energy such as hydroelectricity, geothermoelectricity and ethyl alcohol.

Wood must be consumed with greater efficiency by means of stoves of the closed-fire type which double efficiency: firewood-producing trees and, finally, to substitute part of the wood consumption by cheap renewable sources of energy such as methane gas and cow manure.

Electricity must also be used with better efficiency; research must be speeded up on other renewable energy sources such as the sun and wind, also capable of producing electricity, as well as on electrical interconnections with neighbouring countries.

7. CONCLUSIONS

A close follow-up of the behaviour of electricity demand and the adequate outfitting of its different projects has permitted CEL to maintain a firm supply to cover national needs.

Wit this implementation policy, priority has been given to the use of natural resources in order to provide all the electric power from such resources. This objective was finally reached in 1979 when the installed capacity based on natural resources met all of El Salvador's requirements of electric power and energy.

The measures taken to maintain dynamic planning for the electrical system results in projections such as those presented in Figures V and VI.

Associated with the generating system, a grid of 115-kV transmission lines has been designed and built to interconnect the generating plants and transport the electricity to the load centers.

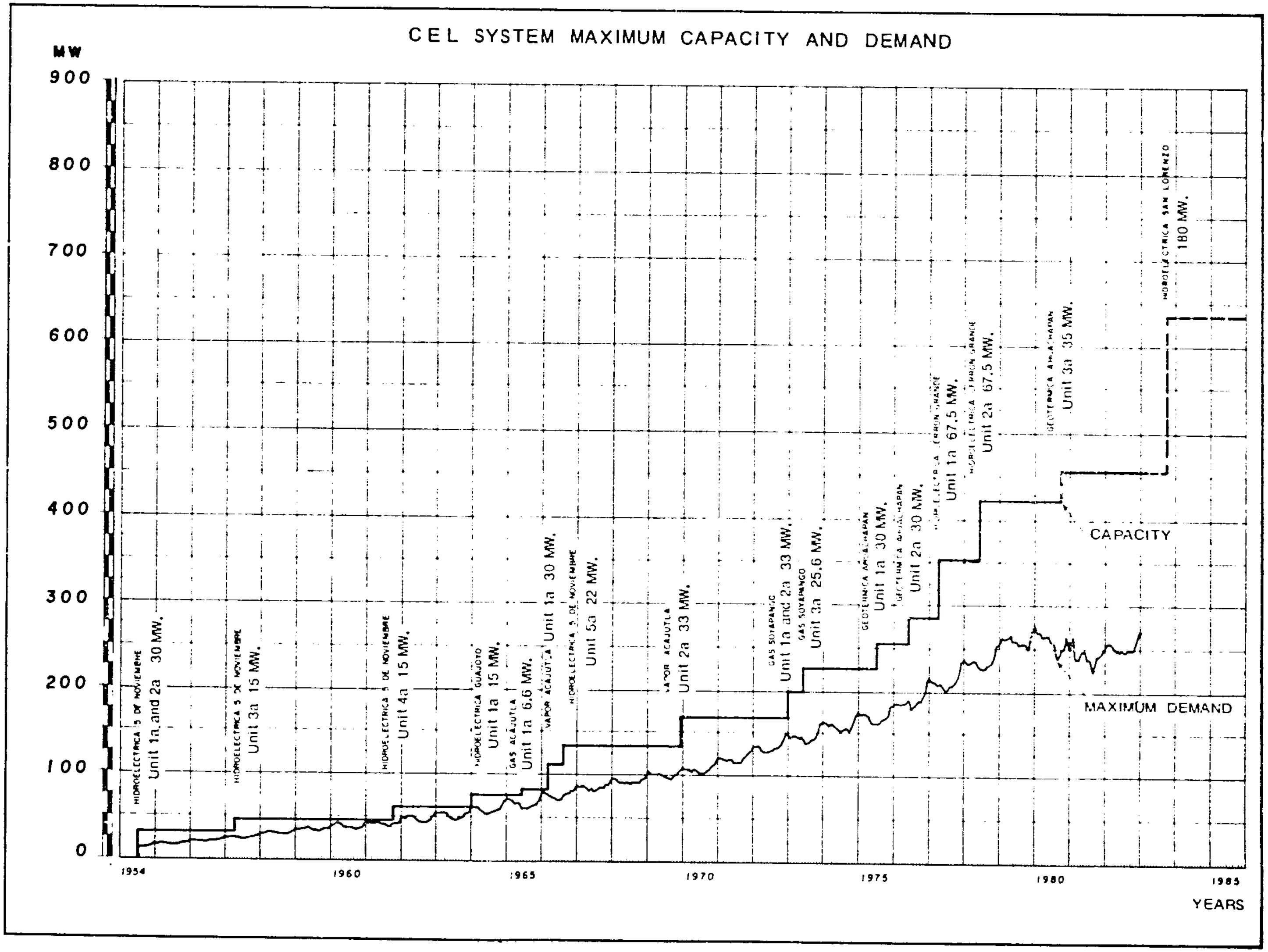
Integrated wit the transmission system, a subtransmission network operating at 44 kV feed, the step-down substations and the related primary distribution lines at 13.2 kV. See Figure VII.

As a complementary unit to the generation and transmission system, a modern Load Dispatch Center has been incorporated to provide for automatic operation of the system. The Load Dispatch Center is 75% complete and has been designed to plan, operate and supervise the generation and transmission system by means of a Real-Time Computer System. This new element in the system will permit more efficient operation thereby improving the resource availability within the load curves.

In El Salvador, CEL has implemented electric power operations and transmission systems in keeping with the socio-economical requirements of the country.

8 INDEX

Figure I



CEL SYSTEM MAXIMUM CAPACITY AND DEMAND
MW
900
800
700
600
500
400
300
200
100
0
1954
1960
1965
1970
1975
1980
1985
YEARS
CAPACITY
MAXIMUM DEMAND
Unit 1a and 2a 30 MW.
Unit 3a 15 MW.
Unit 4a 15 MW.
Unit 1a 15 MW.
Unit 1a 6.6 MW.
Unit 1a 30 MW.
Unit 5a 22 MW.
Unit 2a 33 MW.
Unit 1a and 2a 33 MW.
Unit 3a 25.6 MW.
Unit 1a 30 MW.
Unit 2a 30 MW.
Unit 1a 67.5 MW.
Unit 2a 67.5 MW.
Unit 3a 35 MW.
180 MW.

Figure II

LEMPA RIVER HYDROELECTRIC USE

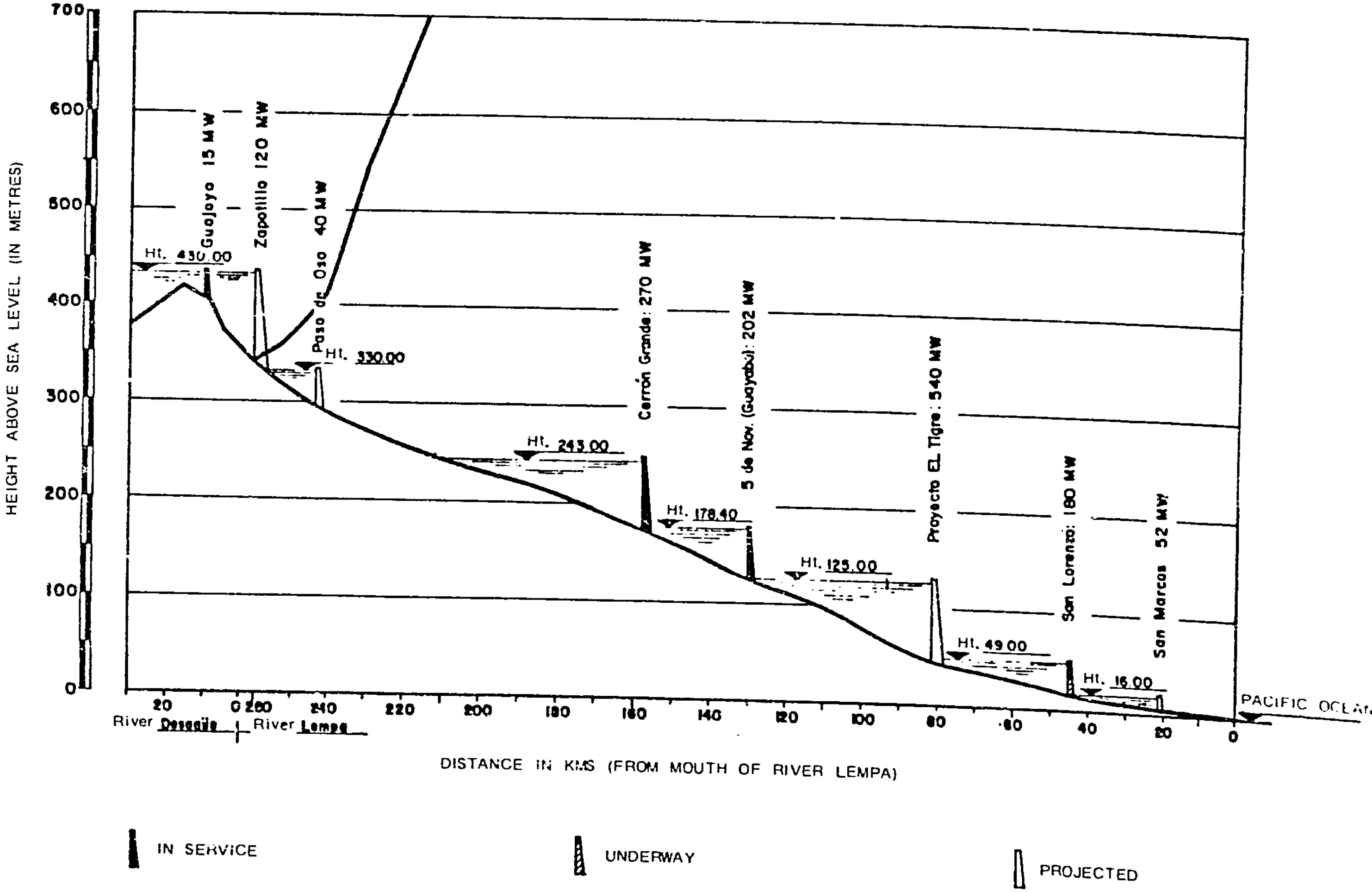


Figure III

STRUCTURE OF INSTALLED CAPACITY ACCORDING TO SOURCES

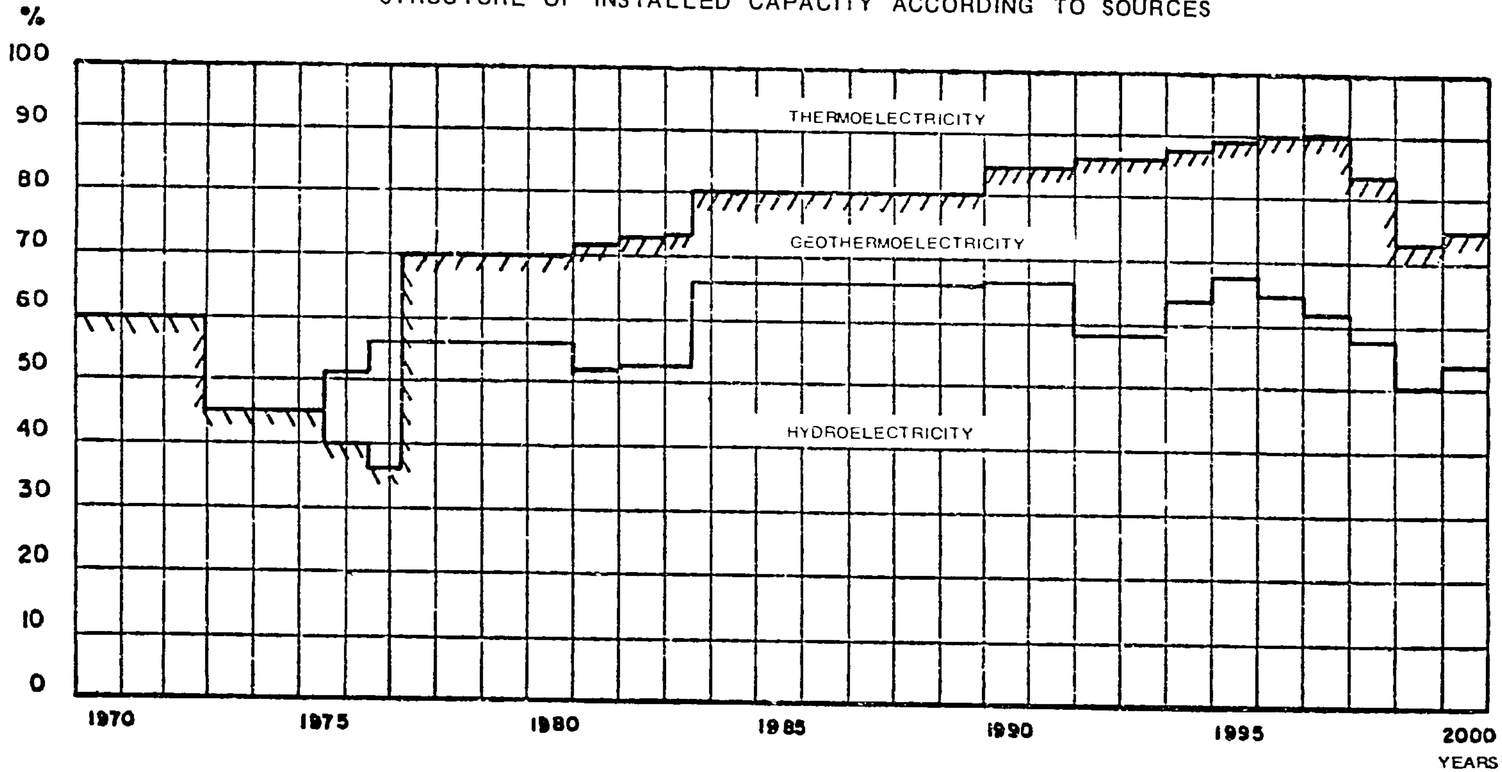


Figure IV

NET ENERGY CONSUMPTION
YEAR 1982

STRUCTURE BY SECTOR

Sector	%	TCAL
INDUSTRIAL	16.5	3,388.3
RESIDENTIAL AND COMMERCIAL	67.7	13,919.0
TRANSPORT	14.2	2,923.6
PUBLIC SECTOR	0.9	182.2
OTHERS	0.7	152.4
TOTAL	100	20,565.5

FORM OF ENERGY

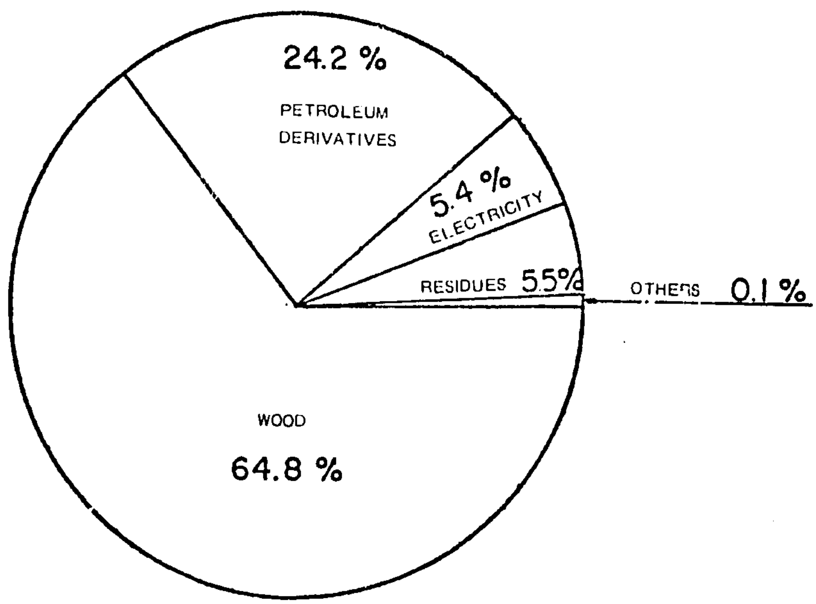


Figure V ELECTRICAL EQUIPMENT
POWER DEMAND AND CAPACITY

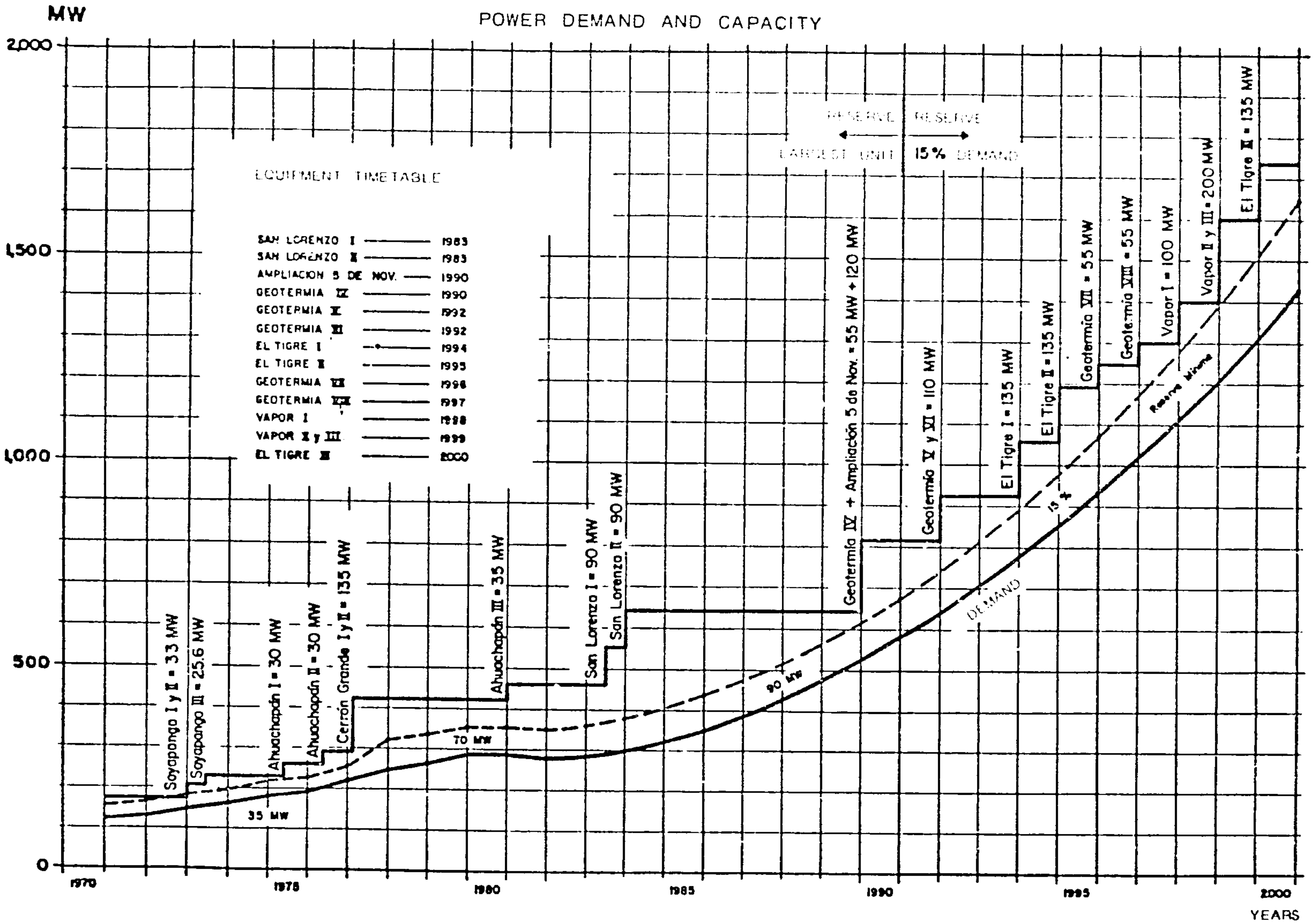
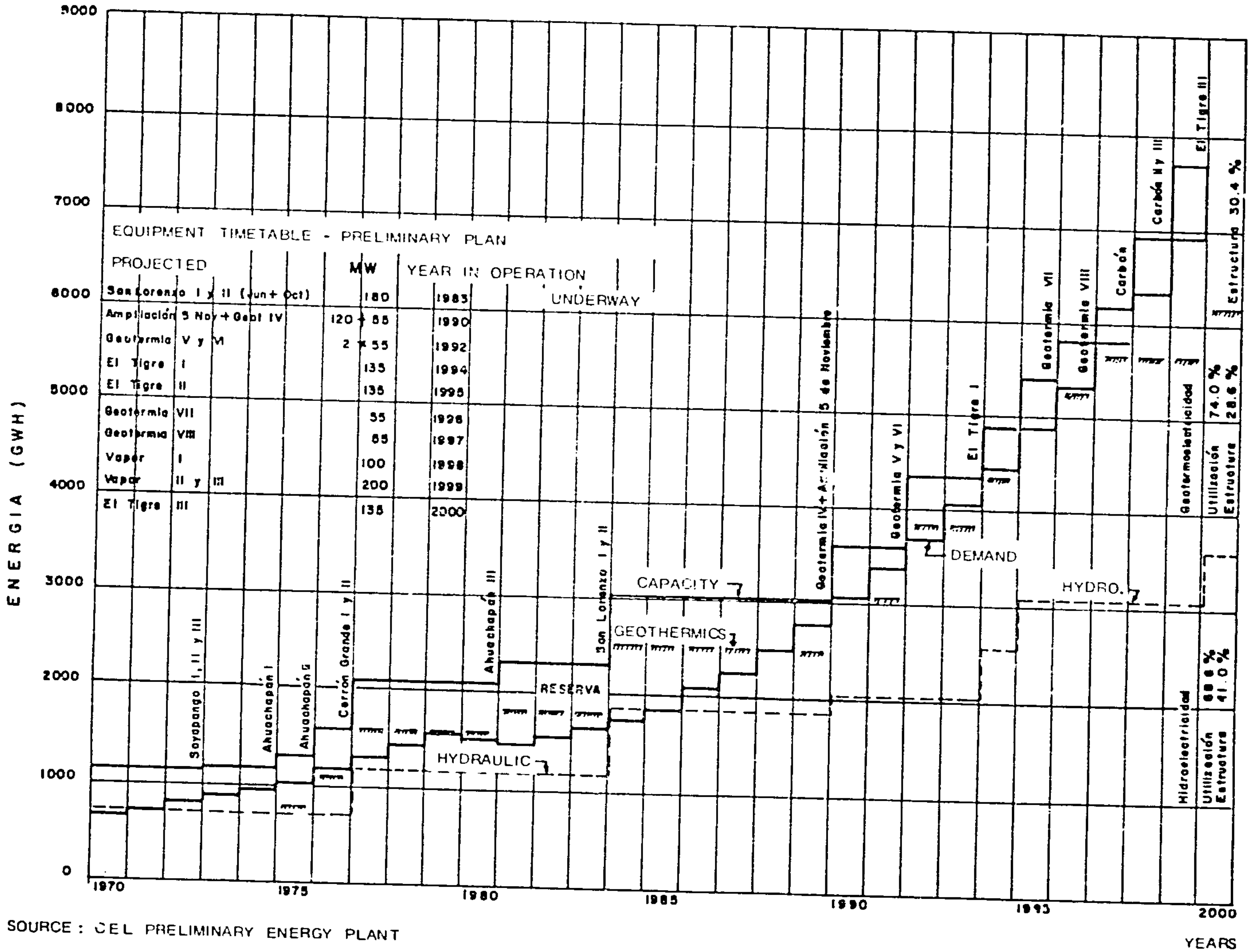


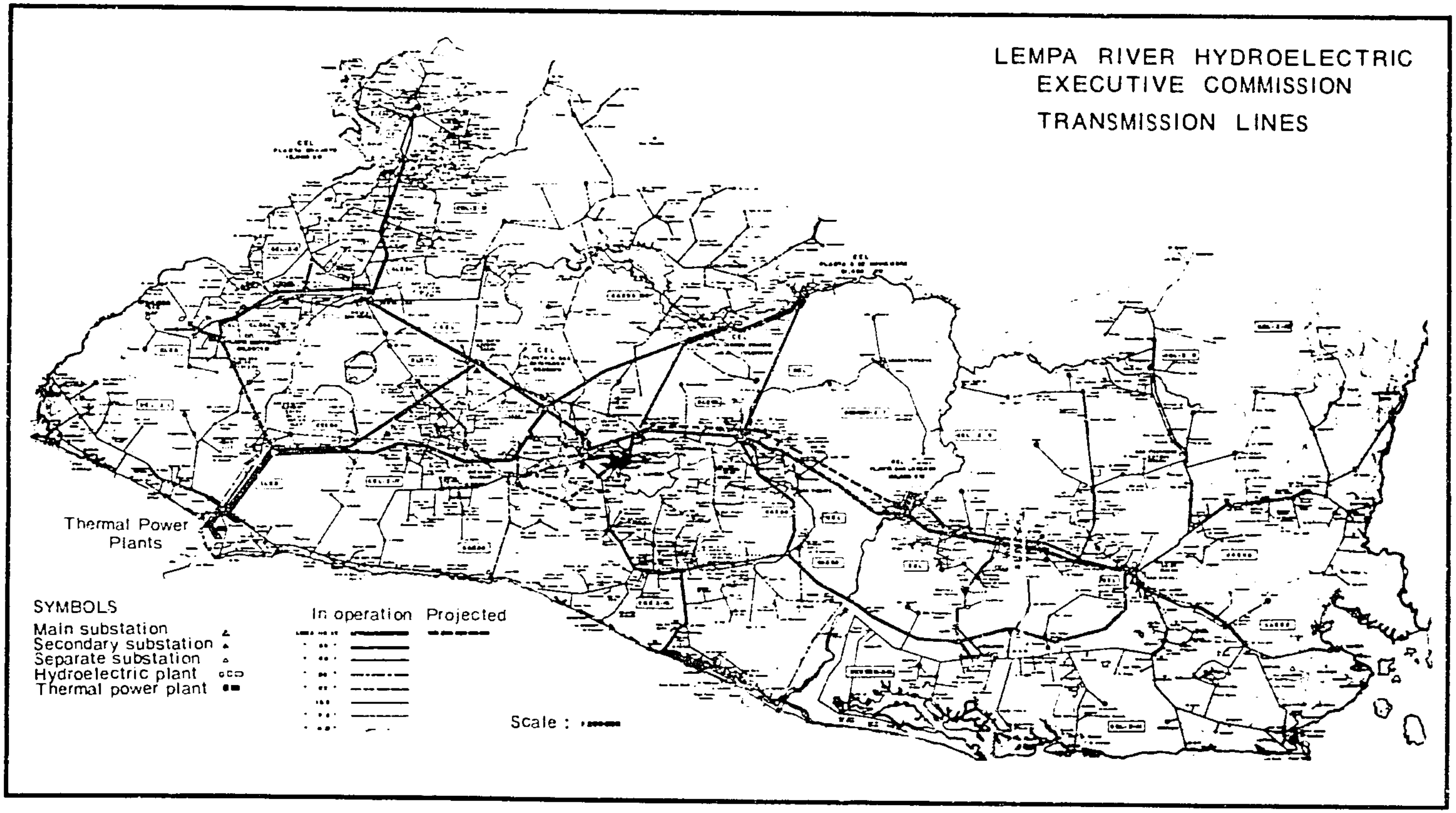
Figure VI

EQUIPMENT OPTION
ENERGY DEMAND AND AVAILABILITY



SOURCE: CEL PRELIMINARY ENERGY PLANT

Figure VII


LEMPA RIVER HYDROELECTRIC
EXECUTIVE COMMISSION
TRANSMISSION LINES
Thermal Power
Plants
SYMBOLS
Main substation
Secondary substation
Separate substation
Hydroelectric plant
Thermal power plant
In operation
Projected
Scale :

RATIONAL UTILIZATION OF ENERGY IN ELECTRICITY PRODUCTION

I. ENERGY CONSUMPTION IN INDUSTRY

In 1981 the energy consumption of the country's industrial sector, by products, was as follows:

	TERACALORIES	%
Electricity	449	15.5
Fuel Oil	1058	36.6
Liquified Gas	29	1.0
Kerosene	28	1.0
Diesel Oil	242	8.4
Coal and Coke	6	0.2
Vegetable Wastes	1079	37.3
	2891	100.0

Source: National Energy Balances, 1970 - 1981. CEL - UNDP

It can be seen very clearly that main products were consumed by industry. First of all, we have oil derivates which represented approximately 47% of total consumption; then vegetable wastes, mainly sugar cane bagasse, which accounted for 37.3% and which was totally consumed by the sugar mills; and finally, electricity with a 15.5% share.

Thus, we can appreciate the large participation of oil products in industrial consumption and the consequent need for rationalization of efforts in this area. Since the country does not have indigenous oil resources, such imports give rise to various problems in the country's balance of payments.

II. THE CURRENT SITUATION OF THE INDUSTRIAL SECTOR

The study of energy as a whole is very recent in El Salvador. Only in 1979 when the National Energy Balances started, through the Energy Programme of the Central American Ithsmus (PEICA), financed by the United Nations Development Programme (UNDP), in collaboration with the Executive Hydroelectric Lempa River Commission (CEL), which created within its organigram an Energy Superintendency in charge of all the energy planning of the country. The aforementioned balances were finished in 1980. Then the elaboration of National Energy Development Alternatives for 1980-2000 got underway. It was possible to make (through the energy balances) a general diagnosis of the situation for all of the energy-consuming sectors, including the industrial sector, but without determining for the latter useful energy efficiency, etc., for each one of the industrial activities.

As for the legal aspect, to date we do not have adequate regulations in this regard and there are no incentives for the enterprises in terms of the utilization of one energy source or another.

Likewise, with the financial aspect, there are no incentives of any kind relative to import duties.

III. THE FUTURE SITUATION OF THE INDUSTRIAL SECTOR

In the field of rational utilization of energy in industry, the urgent need to carry out more in-depth studies has been stressed for the purpose of determining the efficiency attained by the different industries in the consumption of energy, possible substitutions between one energy source and another, as well as the cost that the industries will have in case they make modifications or changes in their current processes. All these questions, and more, would have to be solved by carrying out audits and studies in the industrial sector.

This is why within the Programme to Reinforce Energy Planning Capacity, which is currently being prepared together with the Inter-American Development Bank (IDB) and the Executive Hydroelectric Lempa River Commission (CEL), a study called "Planning for Energy Conservation and Audits" has been foreseen, including the study of energy consumption in the industrial sector.

Also, as a general policy it is felt that since the country has, at this moment, its own natural resources for electricity generation, the industries should look to the intensive use of electricity as a substitute for oil derivatives; and this is already occurring in reality. Moreover, the critical period that the country is passing through has to be highlighted since it has enormously affected the industrial sector.

The private sector, for its part, in collaboration with the Central American Institute of Research and Industrial Technology (ICAITI), is about to undertake a series of energy audits in the majority of the industrial firms.

As has been briefly explained, El Salvador does not have a definite policy for the public or private sector in relation to rational utilizaion of energy in the industrial sector. For the future there are plans to carry out audits and studies on rational utilization of energy in industry. It is known that the industrial sector consumes large quantities of fuel oil which, being an oil product, is imported. Therefore it is necessary to rationalize its use.

Finally, it is important to emphasize the good intentions for receiving financial and technical assistance from other countries or institutions which already have programmes of this kind, and which are ready to share their knowledge in this area.

Knut Berge
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Options to improve fuel efficiency and coal use in electricity generation, combined heat, and power generation

Introduction

Traditionally, the four Nordic countries - Finland, Sweden, Norway, and Denmark - have a high specific energy consumption per capita, partly due to the high heating demands caused by the climatic conditions.

During the last decade, decisive measures have been taken in all four countries to reduce the specific energy consumption and to reduce the usage of oil.

Unlike the three other countries, Denmark has a very low degree of self-supply of energy, and is today dependent on energy imports for more than 90 % of its primary energy requirements.

In the period 1972-1980 there was a real GNP increase of 18 %, but energy consumption remained unchanged, as shown in figure 1.

The vulnerability of Denmark as regards possible failure of oil supplies and the prospect of oil imports becoming an ever-increasing strain on the balance of foreign payments are decisive motives for this policy.

The oil share of the energy consumption has been reduced by switching to coal, primary by the utilities, who are responsible for electricity production as well as serve a considerable portion of the heating market with district and industrial heating from CHP-units.

Further cutbacks in oil demand will be realized in future years by extending the heat supply systems from the power plants, and by the establishment of a natural gas system.

The gas will be supplied from the Danish sector of the North Sea, and will primarily cover heating demands.

The energy consumption by the different sectors are shown in figure 2 for the year 1981, together with a forecast for the year 2000. The expected increase in the fuel consumption for the electricity production is due to extended CHP-production, electric heating of houses that can not be supplied with natural gas or heat from CHP-plants and the electrification of the public railways.

Electricity Consumption in Denmark

The relative shares of the sale of electricity to different types of consumers 1981 are shown in figure 3, and the development in the per capita electricity consumption is represented in figure 4. From this can be seen that a stagnation in the specific consumption has been achieved in the last years due to general savings and the adoptation of less energy-consuming equipment, especially in the domestic sector.

A comparison with the per capita electricity consumption in some selected countries is shown in figure 5. From this can be seen that the consumption in Denmark is very near to the mean value of the 10 EEC-countries, but considerably lower than the average consumption of the Nordic countries. As the other Nordic countries have a long tradition for electricity based on hydro power, the following low electricity prices have initiated the development of heavy electricity consuming industries, like metal melting, which are not found in Denmark.

Energy sources for Electricity Generation

Figure 6 shows the different energy sources used for electricity generation, divided into finite and renewable energy sources.

In the Nordic countries, all kinds of finite energy sources are utilized, together with renewable sources like hydro, wind, and bio matter as peat and wood. Methods for utilizing wave and solar energy for electricity production are currently being developed, especially for local supply at remote places like smaller islands.

The power systems of the Nordic countries differs very much from each other, due to natural conditions and established traditions.

In Norway hydro power is entirely predominant while thermal power is predominant in Denmark.

Sweden and Finland have combinations of both hydro and thermal power. Thermal power is in Denmark based entirely upon coal and oil, and in Sweden and Finland upon coal, oil, and nuclear energy.

In the total system hydro power accounts for the major portion of the total production of electricity, but an increasingly greater share is being based upon nuclear energy and coal. Figure 7 shows the power production in the years 1979-80 in the four countries, as well as the relative shares of the hydro and the thermal power.

Power Exchange among the Nordic Countries

The mutual Nordic electric power cooperation, generally called NORDEL, has a long and established tradition. The four countries, Norway, Sweden, Finland, and Denmark, are linked together with a number of sea cables as well as overhead lines, as shown in figure 8.

As the power systems of the Nordic countries are very different from one another, the advantages of joint operation are considerable.

The overall objective of the cooperation is to reduce the total costs. If each of the countries were to maintain production solely for its own requirements, without an exchange with neighbouring countries, the total cost would be appreciably higher. Besides the higher cost, more oil would have to be used for the electricity production.

This system of cooperation, in addition, contributes toward maintaining a high level of operating reliability.

Since the exchange of power can be expected to flow just as often in the one direction as the other, it is reasonable and generally accepted that any resulting profits be shared equally between the two parties involved.

Electricity Generation in Denmark

Electricity is produced at 19 power stations, all situated at the coast, as shown in figure 9.

The power companies are organized in two powerpools, ELSAM and ELKRAFT.

All generating units are fossil fueled, and so far, no decision is taken on introducing nuclear power.

In 1973, out of a total capacity of approximately 5500 MW, about 3000 MW were coal fired units. Following the sudden increases in oil prices, as much of the existing coal fired capacity as possible was put back into operation. This capacity included, however, many smaller, old-aged units with a high specific heat consumption.

Due to the rising price difference between imported oil and coal, and a desire to reduce oil dependence, the utilities initiated an extensive oil to coal conversion programme, which includes:

- Retrofits
- Conversions
- New units.

Retrofits

A number of units being built in the sixties were designed for coal, but equipped for oil firing only. The conversion programme includes the retrofitting of all these units to coal as shown in table I.

Typical recorded outage time for each unit has been 6-8 months.

The retrofittings typically include:

- Coal import harbour with unloaders
- Coal transport and storage systems
- Coal grinding and firing equipment
- Soot blowers
- Precipitators
- Ash handling and storage.

On the average, the specific conversion cost has been about 100 US$/kW.

After re-commissioning on coal firing, due to the coal prices being considerable lower than the oil prices, the evaluated pay-back time for the retrofits has typically been 2 years.

Conversions

All units under construction or commissioning in 1973 were designed for oil firing only. Preliminary studies were performed by the utilities on how to convert these units to coal firing. A number of units proved to be impossible to convert due to prohibitive space limitations on the site. Others were judged to be possible, and after detailed studies, decisions covering 4 conversions were taken as shown in table II.

A prerequisite in all the conversion projects has been that a full rating should be maintained on coal (as well as oil) firing.

The first of these conversions was performed at Unit 4 of Fynsvaerket Power Station.

This unit was originally commissioned 1974 and had 22,000 running hours on oil firing before it was taken out of operation for the conversion. Figure 10 shows the original oil fired compact type boiler and the converted coal fired boiler.

This project included:

- Excavation to 10 meters below ground level to accomodate the bottom ash hopper.
- Installment of separate primary air preheater due to the increased total air demand.
- Extension of boiler house to provide sufficient space for coal hoppers, feeders, and pulverizers.
- Coal transport system.
- Coal firing system.
- Soot blowing system.
- Electrostatic precipitator.
- Ash handling and storage silos.

Total outage time was 18 months, and total conversion costs amounted to 30 million US$. Pay-back time was less than 2 years.

The unit is operated on a CHP-scheme, supplying heat to the city of Odense.

The fuel efficiency of the unit varies from 40 % on power production only up to 80 % on combined heat and power production. The recorded average yearly efficiency is approximately 67 %.

The second conversion project was performed at Unit 5 of Asnaes Power Plant.

This unit was due to be commissioned in early 1980. However, in early 1978 it was decided to convert to 100 % coal firing. At that time, boiler house was completed, and most of the boiler was erected. Figure 11 shows the original single pass oil fired boiler and the converted two-pass coal fired boiler. In addition to the same items listed for the Fynsvaerket project, the conversion included a 100 % extension of the boiler house.

As the decision on conversion of this unit was taken during the construction period, exact cost and outage time can not be established. The pay-back time is estimated to 4 years, including all costs related to the conversion.

New Coal fired Units

To cover the projected increase in electricity consumption, substitution of retired units and to secure the heat supply from CHP-units a number of new units have been included in the oil to coal conversion programme, as shown in table III.

Coal Supply to Denmark

Steam coals are imported from all over the world. The total import amounts to 8-10 million tons/year.

Unlike other fuels like oil and gas, coal is by nature a heterogenous substance whose composition and properties varies a lot between the different origines. Even within a single lump of coal there can be significant variations.

The global origines of the coal supply implies that a variety of different coals with different physical and chemical properties are utilized. This often results in different (and in some cases very strange) behaviour in the boilers as well as in the coal supply system. Some coals require mixing with others before being utilized on a specific unit.

In coal producing countries, the users base their selection of equipment on the coal characteristics from the nearby mines with due respect to earlier experiencies.

For a coal importing country, the keyword in plant design is flexibility with as few limitations as possible relative to the spectral variations in coal characteristics on a global basis.

In the plant design, compromises must be done, but preferably with a minimum of limitations for the coal purchaser when he faces the coal market.

It is not only a strong desire, but a necessity of importing nations to diversify their sources of delivery, to minimize the risks of supply failures during crisis.

In the case of Denmark, the changing import pattern during the last few years is shown in figure 12. Typical problems and constraints in this period have been the political disturbances in Poland, the frequent strikes in Australia, the crowded US-harbours, and an appeal from the Danish government to minimize the import from South-Africa.

A number of new harbours with associated coal terminals have been constructed in the last years, including two major terminals designed to accomodate fully loaded bulk carriers up to a size of 170,000 dwt.

Long term contracts have been placed in a number of countries including Columbia, to secure the coal supply, in combination with local coal yard storage on each of the stations.

Results of the Danish Coal Expension

The total conversion programmes in terms of generating capacity is shown in figure 13.

The achievements so far in the efforts against the ultimate goal - minimizing the oil consumption - is shown in figure 14. From oil having an 80 % portion of the fuel consumption, this is now reduced to 8 %.

Combined Heat and Power Production in Denmark

In Denmark, about one third of all houses have a district heating connection which is regarded as being a most ordinary installation, just as any other utility connection such as water, electricity, and gas.

Co-generation of electricity and heat was introduced in the 1920's and was developed along with the extension of the electricity supply. The first units were based on diesel generators, but later, as larger units became necessary, steam turbines were introduced. Today, about 10 % of the total consumption for space heating is covered by combined heat and power plants, and according to existing plans, this will be increased to approximately 25 % during the next 10 years. Compared to a system where electricity and district heating are produced separately, the total savings amount to approximately 1 million ton oil per year. Besides, the extension of power plant heat systems will further reduce the oil consumption, as the combined heat and power plants to a great extent utilize coal.

In a modern coal-fired steam-unit the thermal efficiency is approximately 40 %. The predominant loss is due to the cooling water, which carries away about 45 % of the fuel input.

In a combined heat and power (CHP) unit, approximately 85 % of the fuel is utilized in the heat and power production.

Big investments in the pipeline net are necessary for the utilization of power plant heat. In return, the fuel consumption is low, which makes the heat costs relatively insensitive to even considerable changes in the fuel price.

In Denmark the total environmental pollution has been reduced due to the introduction of CHP-units, partly because of the reduction in the total fuel quantity being burned, and partly because of the power stations being situated remote from the city centres.

The heat supply of the country is regulated by a legislation, giving the central and local authorities means to issue directives concerning the regional heat supply systems to be adopted.

Such directives will be issued after local heat plans have been worked out and discussed with the parties involved.

These plans will often cross the existing administrative borders and must finally be coordinated and approved by the Minister of Energy with the aim of securing a market for the collective heat supply in accordance with the superior aims of the energy policy.

If the accomplishment of a certain heat supply project is necessitated by superior energy political objectives and also less profitable than other alternative heat supply methods, the approval of such a project must at the same time imply guarantees for sufficient Governmental grants.

The purpose of the legislation on heat supply is to secure that the utilization of energy for heating of buildings, hot water supply, etc. and other use of low-temperature energy takes place according to a total planning, which forms part of the total energy planning of the country and to supply the necessary administrative basis for the planning.

The heat supply planning is done out of consideration for the reduction of the vulnerability of the energy supply, and especially the dependency on oil supplies, and assist in the slowing down of the growth in use of energy, the encouragement of an optimum use of energy resources, and the reduction of the environmental impact.

A characteristic feature of Danish district heating systems is the fact that low temperatures are used, whereby several advantages are achieved, such as better economy at combined production due to lower condensation temperature, lower heat loss in the network, simpler duct constructions and direct house connections without expensive heat exchangers and control equipment. This results in lower initial and running costs, which is one of the important reasons of the high coverage of district heating and combined production in Denmark.

Other Uses of Waste Heat from Power Plants

Due to the climatic conditions in Denmark, the production of vegetables in green houses is very energy consuming. As an example, the yearly average consumption to grow 1 kg tomatoes is about 1 kg oil. Substitution of oil based direct heating by utilizing heat from the power stations are currently being investigated. Such systems are already successfully in operation at some of the power stations.

After passing through the turbine condensors, the temperature of the cooling water is increased by 5-8°C, which makes it ideal for aquaculture. A number of farms for raising fish and oysters have been planned, and some test plants, like the one shown in figure 16, are in operation.

Besides district heating, where the normal heat carrying medium is water, some of the power stations deliver steam extracted from the turbines, to near-by industries for process uses.

Suggestions for Action for Utilities and Governments

The experiences acquired by the Danish utilities in the field of oil to coal conversion and the development of combined heat and power generation are based on the local conditions, and can not directly be used for general recommendations.

However, many of the problems involved have been of universal nature and some statements can be made:

Fuel can be saved and the environmental impact reduced by:

- Investments and other measures aimed of reducing losses in the individual parts of the generating units.

- Preventive maintenance and other precautions to secure proper plant functioning and high availability. This is especially important on coal fired plants.

- Introduction of combined heat and power production.

In the field of electricity generation, substantial savings can be achieved through cooperation including power exchange between utilities and neighbouring countries.

In connection to major changes in the fuel supply, such as a massive oil to coal conversion, a close cooperation between utilities and authorities is necessary to effectively solve problems of general nature, such as those related to financing, fuel supply security and environmental impacts.

As the coal qualities and combustion characteristics varies very much from the different origines, it is essential that the design of a coal fired unit is based on a realistic coal supply scheme.

In connection with larger shifts in the forms of heat supply, such as district heating supplied from combined heat and power stations, an effective information including the consumers, the producers, and the authorities is an essential part.

For oil to coal conversion as well as introduction of combined heat and power systems, it is important that this is guided by a firm governmental energy planning, including a consistent energy tax policy supporting the planning.

---oOo---

Abbreviations used

GNP:	Gross National Product
CHP:	Combined Heat and Power
EEC:	European Economic Communities
US:	United States of America
FRG:	Federal Republic of Germany
NORDEL:	Cooperation body for power supply in the Nordic countries
DEF:	The Danish Association of Electricity Supply Undertakings
kW:	kilowatt (10^3 watt)
MW:	megawatt (10^6 watt)
PJ:	Petajoule (10^{15} Joule)
ton:	metric ton (10^3 kg)
TOE:	Tons Oil Equivalent
Outage time:	The total time when a unit is not available for power production.

The Danish Utilities' Oil to Coal Conversion Programme

Table I

Retrofits

Power station name	Unit No.	Unit size MW	Year of commissioning	Conversion completed	Outage time Months
Asnæs	4	268	1968	1978	7
Vestkraft	2	268	1969	1979	6
Stigsnæs	2	285	1970	1980	8
Skærbæk	2	285	1971	1981	7
NEFO	1	137	1967	1982	6
Stigsnæs	1	150	1966	1983	16
Total		1393			

Table II

Conversions

Power station name	Unit No.	Unit size MW	Year of commissioning	Conversion completed	Outage time Months
Fynsværket	3	285	1974	1980	18
Asnæs	5	698	1981	1981	
Nordkraft	1	285	1973	1985/86	25
NEFO	2	305	1977	1985/86	25
Total		1573			

Table III

New units

Power station name	Unit No.	Unit size MW	Year of commissioning
Ensted	3	630	1979
Herning	1	95	1982
Randers	1	50	1982
Studstrup	3	375	1984
Studstrup	4	375	1985
H.C.Ørsted	7	90	1985
Total		1615	

Figure 1

Mio. T.O.E. DENMARK - total fuel consumption

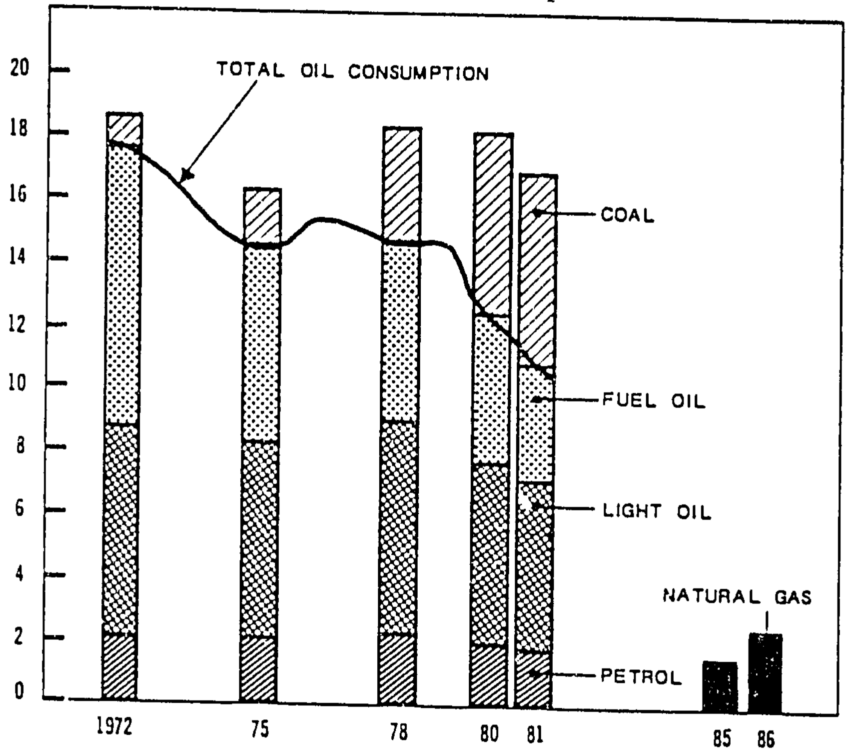


Figure 2

DENMARK - energy concumption by sectors
(1981 and 2000)
Source: Danish Energy Ministry

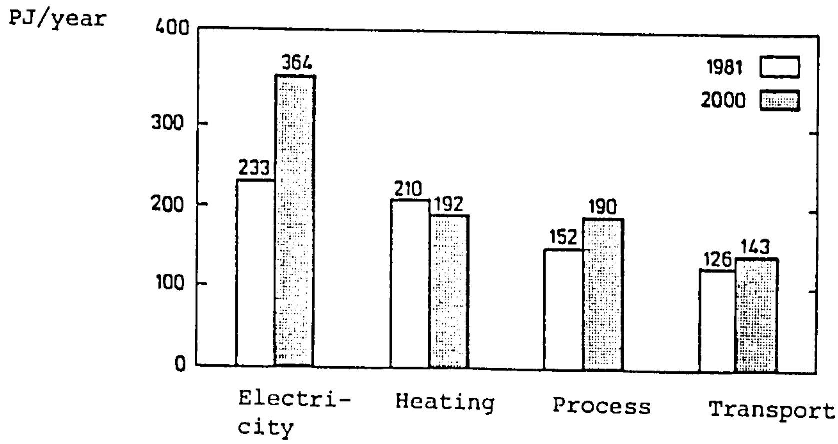


Figure 3

Sales to consumers 1981:

Source: DEF

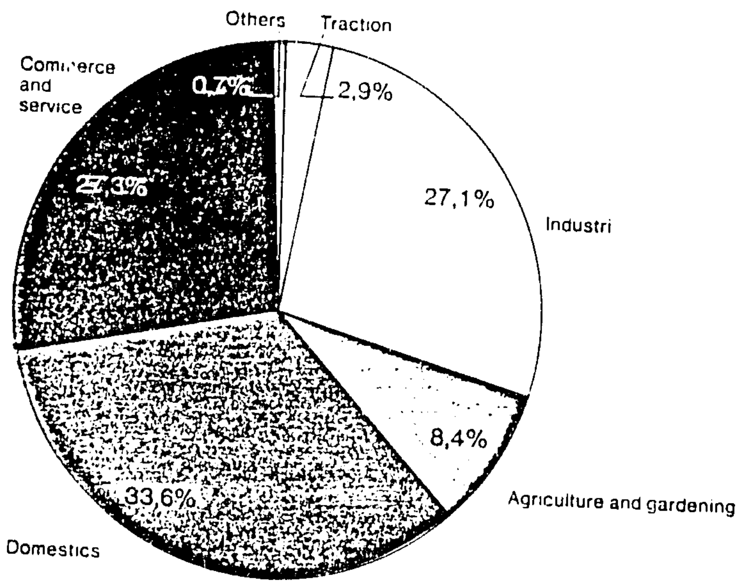


Figure 4

Per capita electricity consumption (incl. network losses) in Denmark. 12 months curve.

Source: DEF

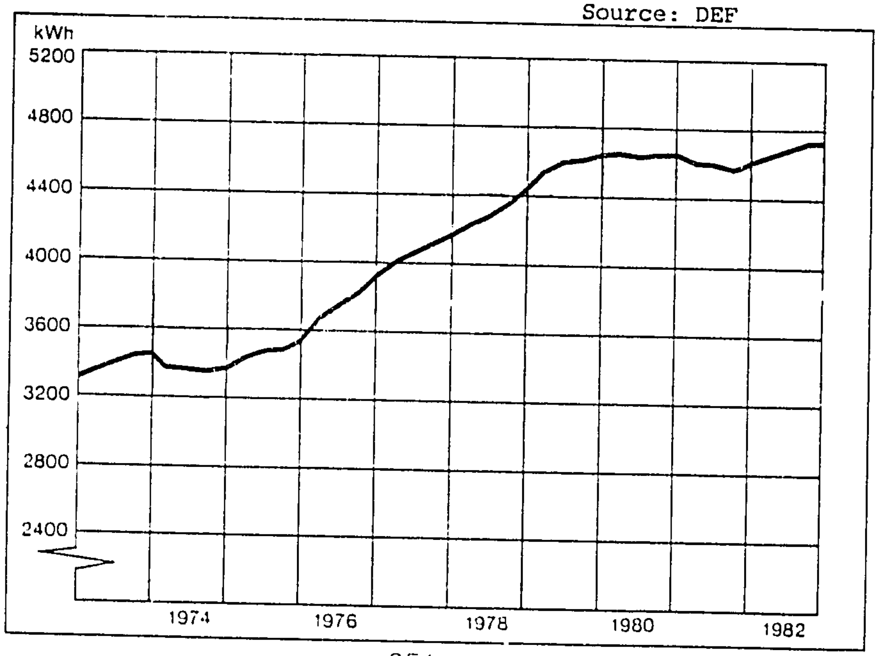


Figure 5

Per capita electricity comsumption in some selected countries, 1982 (kWh per capita).

Source: NORDEL
EEC

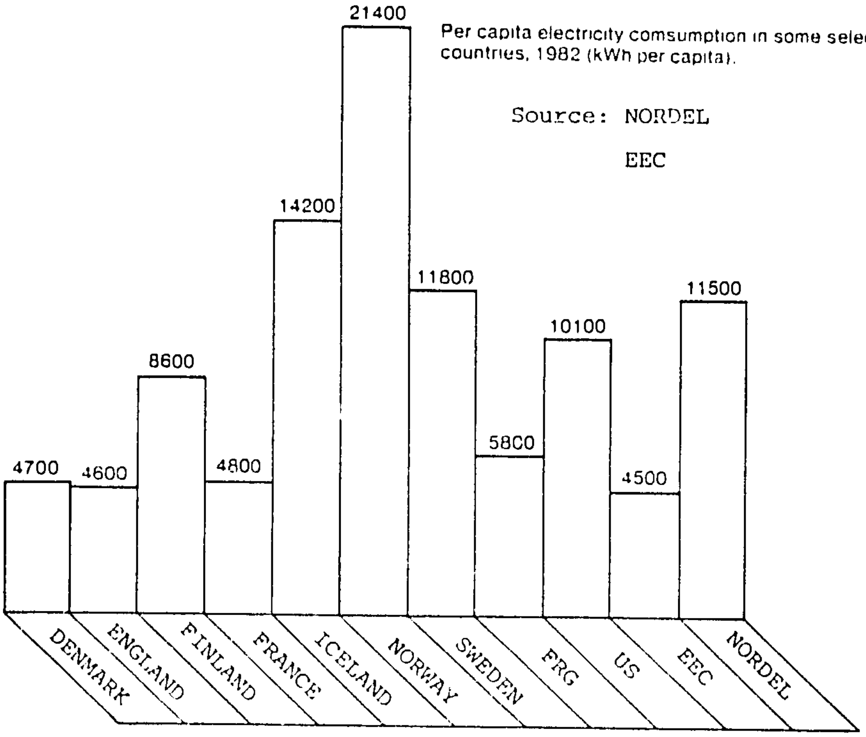


Figure 6

DIFFERENT ENERGY SOURCES USED FOR ELECTRICITY GENERATION. (EVENTUALLY IN COMBINATION WITH HEAT PRODUCTION.)

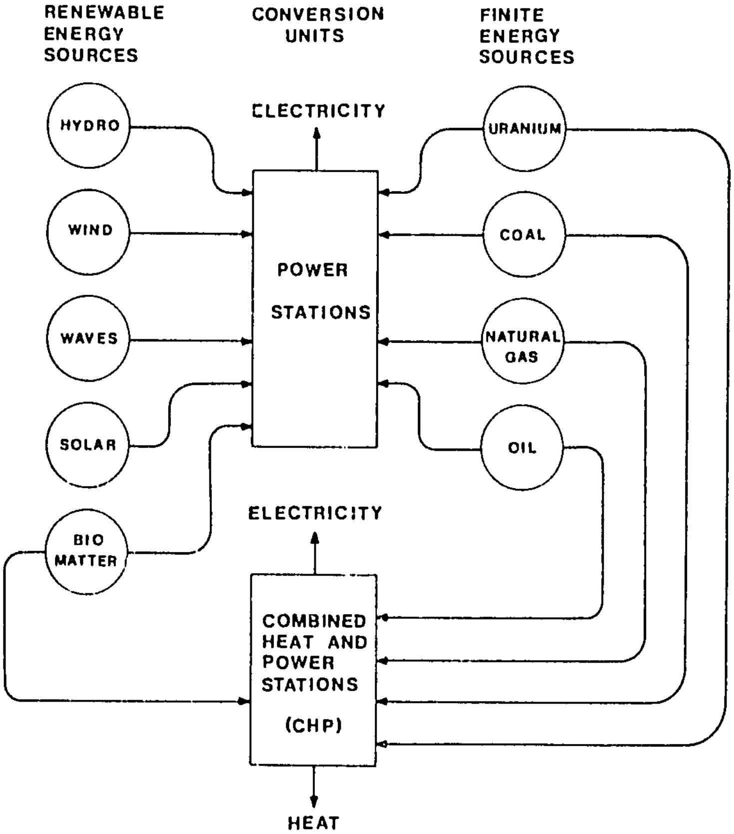


Figure 7

Source: NORDEL

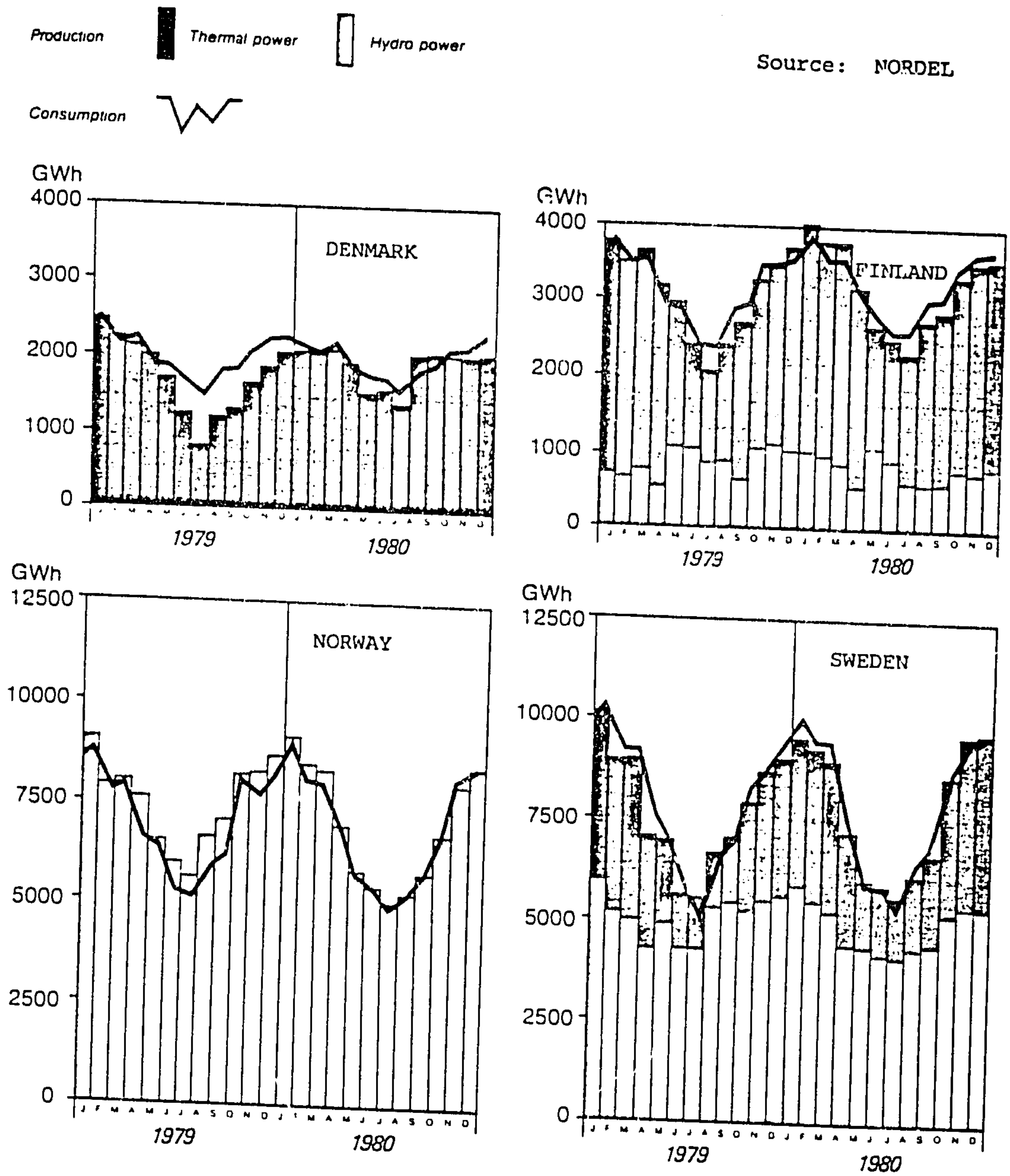


Figure 8

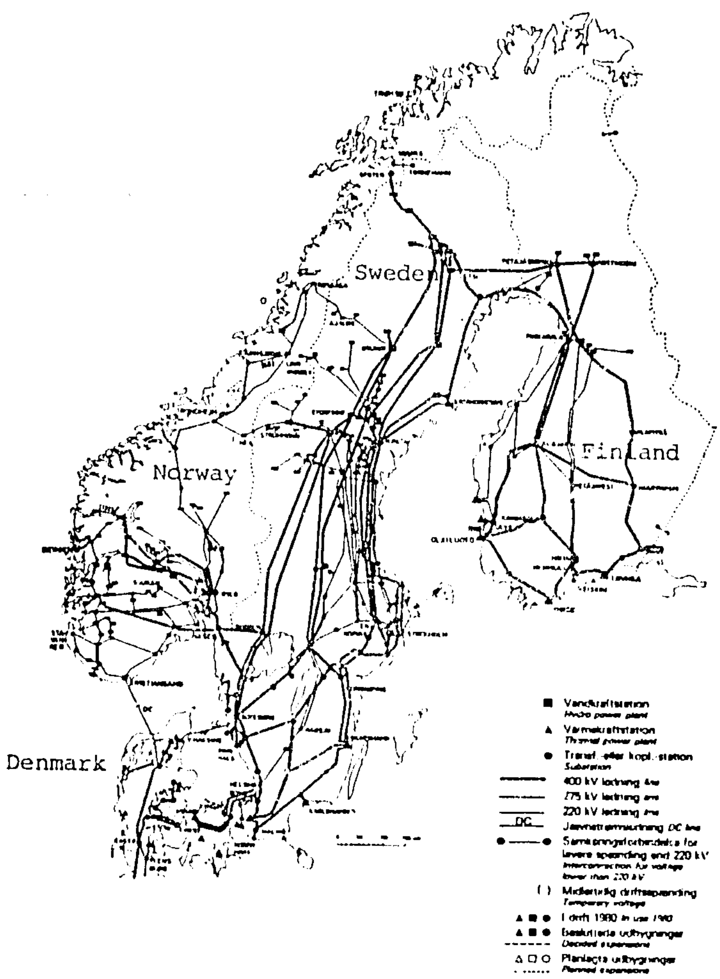
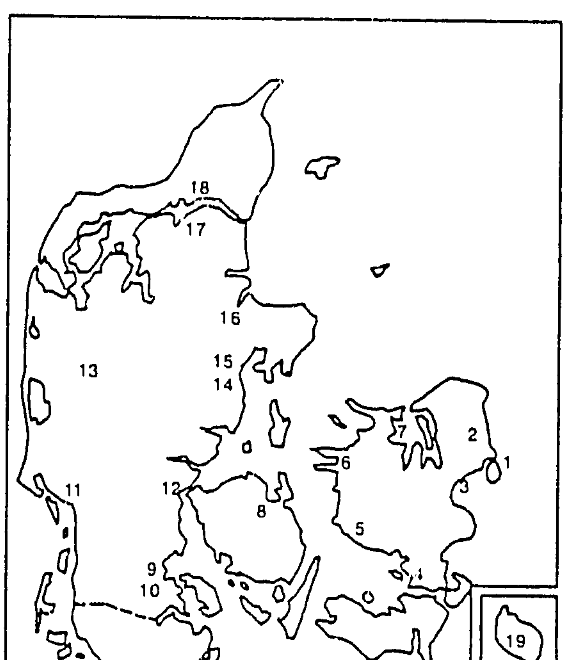


Figure 9

LOCATION OF CENTRAL POWER STATIONS IN DENMARK



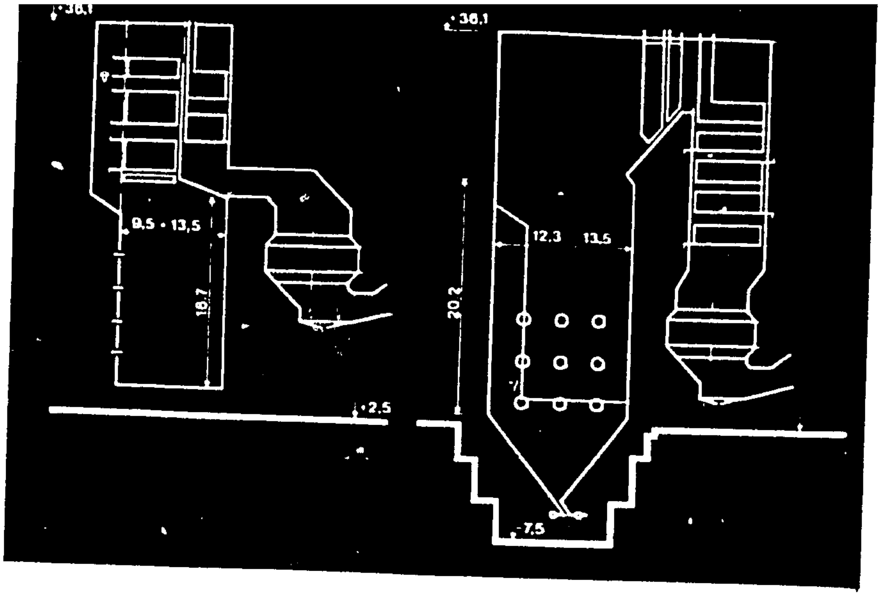


Figure 10

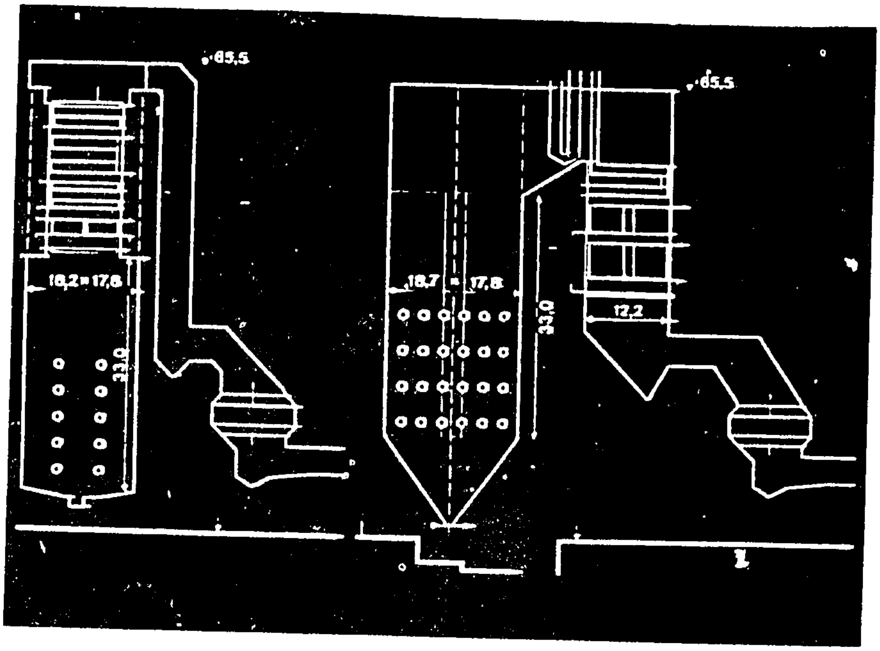


Figure 11

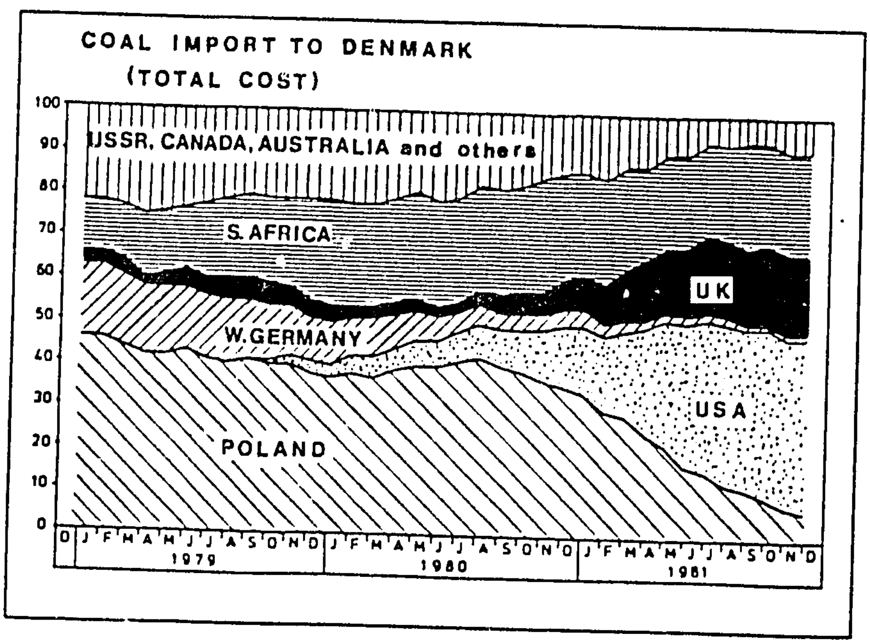


Figure 12

Figure 13

DANISH POWER STATIONS - ELECTRICAL CAPACITY

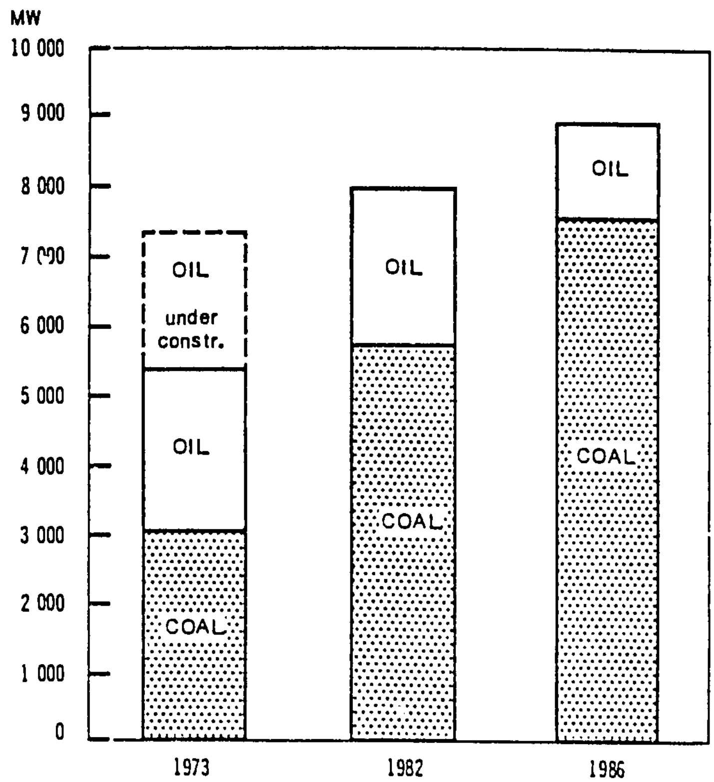


Figure 14

DANISH POWER STATIONS - POWER PRODUCED FROM COAL AND OIL

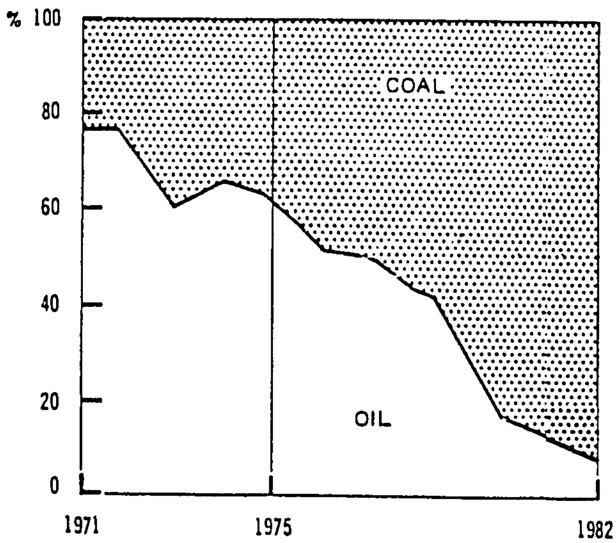
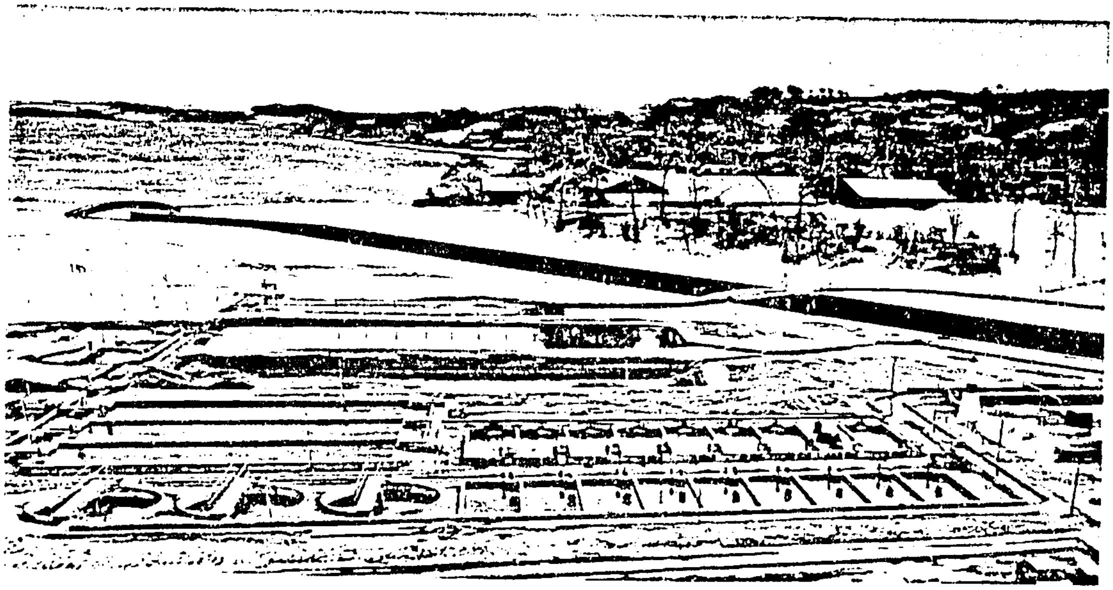


Figure 15

DENMARK - Fish Farm at Ensted Power Station.



THE USE OF ENERGY IN SIDOR

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A.1 INTRODUCTION

Venezuela embarked upon the iron and steel industry in the mid-1950's, when it decided to install an iron and steel complex in the Matanzas area of the State of Bolívar and built the Orinoco Iron and Steel Plant (SIDOR). From that moment onwards, and throughout all the later stages of expansion and modernization of the firm, the energy parameter has been present. In selecting the most profitable processes, the great abundance and easy access to most of the resources necessary for operating an iron and steel complex were taken into account. Nevertheless, the primary consideration taken into account was that related to energy availability.

The original plant was designed with a capacity of 750,000 tons per year. At that time, the most highly developed technology was adopted for manufacturing steel, i.e., the Siemes Martin steel-making process and the subsequent lamination processes. Afterwards, in the mid-1970's, it was decided to expand the capacity to 4.8 million tons per year; and, once again, it was the energy factor that weighed heavily in deciding abount the production processes to be used. In sum, it can be said that from the time of its conception and during its later development, SIDOR has considered of vital importance the availability of, and access to, the energy resources of the area in which the plant has been installed.

B. OBJECTIVES

B.1 To present energy-related considerations that have prevailed in the installation and expansion of SIDOR.

B.2 To present the situation of SIDOR from the standpoint of rationalization of the use of energy.

C. DEVELOPMENT

C.1 Description of the Original Plant

SIDOR is located in Matanzas, in the State of Bolívar, Venezuela, in the southeastern part of the ocuntry, at the point of confluence of the Caroni and Orinoco Rivers. Its location is noteworthy since it proves extremely advantageous; in a 400-km. radius easily-accessible reasources, necessary for the development of an iron and steem comples, can be found, with the sole exception of coke. This apparent drawback is compensated by the large hydroelectric potential of the zone, where an installed capacity of 1315 MW already exists, with prospects for expansion to 8200 MW.

Initially, the following plants were installed:

1.1 Sintering Plant
1.2 Pig Iron Plant
1.3 Siemen Martin Steel Mill
1.4 Primary Lamination, Bars and Rolled Steel Plant
1.5 Piping Plant
1.6 Wire Drawing Plant
1.7 Foundry

C.1.1 Sintering Plant: This consists of a machine with a surface area of 100 m^2 and an installed capacity of 3000 tons per day.

C.1.2 Pig Iron Plant: This conssits of 9 electric furnaces of the Tysland Hle reduction type with 33,000 kVa each and a production capacity of 200 tons per day in each furnace. These furnaces use coke as the reducing agent and electricity as the heat source, with an average load of 22,500 kW per furnace. In addition, there is a workshop for the manufacture of electrodes having a capacity of 8000 tons per year and an ingot-molder with a capacity of 2500 tons per day.

C.1.3 Siemes Martin Steel: This unit consists of four furnaces whose capacity was increased from 250 tons each, with a LOFTUS design.

C.1.4 Primary Lamination, Baras and Rolled Steel Plant: This consists of four laminators or rolling mills: one reversible a 1100-mm one, and another 800 mm one, and 3 frames; a 500-mm laminator with a trio of trimming, laminating frames; and a set of three frames and a 300-mm. laminator. It also includes ten pit furnaces with a 125-ton ingot capacity each and re-heating furnaces for each plant.

C.1.5 Piping Plant: This consists of three plants with the following features:

- Large Plant: With two frames, for hot-rolling pipes without seams with a pilgrim pitch with a diameter of 8-5/8 to 16".

- Medium Plant: With two frames for hot-rolling pipes without seams at the pilgrim pitch with a diameter of 3-1/2 to 7".

- Small Plant: With a reducer for the manufacture of pipes without seams with a diameter of from 2-3/8 to 4-1/2".

C.1.6 Wire Drawing Plant: This consists of three units for prestretching wire, fourteen units for wire drawing, thirty-two machines to manufacture barbed wire, and two lines for hot-dip galvanization.

C.1.7 Foundry: This plant is used ofr casting pieces and parts, mainly ingot molds and plates. For this, there are installations for handling and preparing the sand and electric-arc furnaces with a 15-ton capacity each. Also, there are two machines for the production of centrifugal tubes, with a capacity of 30,000 tons per year and diameters between 60 and 300 mm.

Furthermore, the original plant has various installations and support services which take part in different aspects in production.

C.2 Modifications and Enlargements

SIDOR has undergone three stages of modification and expansion of its facilities. All of them included energy considerations in the corresponding analyses. These stages have been:

2.1 Expansion of the capacity of the Siemens Martin Steel Mill
2.2 Construction of the Flat Products Plant
2.3 Plan IV

C.2.1 Expansion of the Capacity of the Siemens Martin Steel Mill: This consisted of an increase in the capacity of the original furnaces, from 250 to 300 tons, including, too, oxygen insulfate and expanding the capacity to 1,200,000 tons per year. This modification was concluded at the end of 1976.

C.2.2 Construction of the Flat Products Plant: This stage began in the early 1970's, and the expansion program is about to be concluded. This plant has facilities for cold- and hot-casting a large variety of products, including sheet metal.

C.2.3 Plan IV: This is the most ambitious project of the company, since it contemplates the enlargement of the steel-making capacity from 1,200,000 ton per year to 4,800,000. This project offers particular characteristics in that not only the expansion of production capacity, as explained, entails a number of problems, but because it also takes on singular importance in terms of the energy aspect. Actually, SIDOR proposed two alternatives: the conventional one, i.e., a furnace, converter to oxygen, with continuous operation, or direct reduction, with electric furnaces and continuous melt. Once the corresponding analysis has been done, SIDOR decided to adopt the direct reduction method, with electric furnaces and continuous operation, and to install the following plants:

2.3.1 Lime Plant
2.3.3 Pellet Plant
2.3.3 Direct Reduction Plant
2.3.4 Steel Mill and Continuous Sheet-making
2.3.5 Steel Mill and Continuous Billet-making
2.3.6 Bars and Wire Plant
2.3.7 Expansion of Flat and Rolled Steel

2.3.1 Lime Plant: This was built fundamentally to manufacture the lime that would be used in the pellets plant as an agglomerate and in the steel-making plant as a desulfurating and dephosphorizing welding compound. The capacity of this installation is 240,000 tons per year.

2.3.2 Pellet Plant: This consists of two grinding and pelletization units with a capacity of 6,600,000 tons per year.

2.3.3 Direct Reduction Plant: This consists of eight modules with a capacity of 3,840,000 tons per year.

2.3.4 Steel-making and continous sheet-making: This consists of six electric-arc furnaces with a total capacity of 2,300,000 tons of liquid steel per year, coupled with three continuous-melt machines with a capacity of 2,200,000 tons of sheets per year.

2.3.5 Steel-making and Continous Billet-making: This consists of four electric-arc furnaces with the capacity to produce 1,200,000 tons of liquid steel per year, coupled with three machines for continuous melt, with a capacity of 1,050,000 tons of billets per year.

2.3.6 Bars and Wire Plant: This consists of a continuous line of wire rods with a capacity of 500,000 tons per year, and a line of bars with a capacity of 700,000 tons per year.

2.3.7 Expansion of the Falt Products and Pipe Manufacturing Plant: Still under development.

As can be seen the magnitude and significance of these enlargements is considerable.

C.3 Considerations in the Expansion of SIDOR

C.3.1 Analysis of Alternatives: The furnace method, the Siemes Martin steel mill and the subsequent lamination processes have constituted since the mid-1960's an obsolete alternative for steel-making. In their place has been developed the furnace method, oxygen-converters and continuous melt. Both the continuous melting as well as the oxygen converters were developed in the decade of the sixties; and with the improvements introduced in the furnace, the use of the two together constitutes the most efficient way to make steel. However, this alternative calls for the existence or availability of coke or cokable coal.

Approximately since that same era, the development of another alternative has been in progress, using direct reduction and continuous-melt electric furnaces for steel-making. This method, less efficient from the energy perspective, constitutes a real possibility in countries in which cokable coals cannot be obtained, as in the case of Venezuela. This was an important element in the decision in favor of the direct reduction electric furnace continuous-melt method for the expansion of SIDOR.

A brief analysis of the availability of energy and material re sources in the country follows.

C.3.1.1 Raw Materials: the following materials participate in a fundamental way in steel-making; coke, iron ore, "welding" componds and refractory agents.

3.1.1.1 Coke: In Venezuela the possibilities for making coke have not yet been clearly defined; in the year 1973, when the expansion project got underway, this situation was even more relevant. There do exist coal deposits in the State of Anzoategui, some 400 kms. away from SIDOR, and other beds in the State of Zulia, in the extreme western part of the country, some 2000 kms. from SIDOR. Work has been going on in these deposits recently, in order to determine the prospects for coking.

3.1.1.2 Iron Ore: SIDOR is situated in an area where iron ore abounds; the estimated reserves amount to some 2.131 billion tons. This mineral is currently exploited by a firm from Orinoco Mining.

3.1.1.3 "Welding" Compounds: In addition to the mineral deposits, abundant deposits of limestone and dolimites are available, thus assuring the supply of these materials.

C.3.1.2 Energy Products: Those normally used in iron and steel plant are as follows: coke, fuel oil, natural gas, and electricity. In the case of SIDOR, both the natural gas and the electricity are inputs whose possibiliteis for use are considerable.

3.1.2.1 Fuel Oil: Several refineries where this kind of fuel can be obtianed are near SIDOR.

3.1.2.2 Natural Gas: The natural gas deposts are found in the State of Anzoategui, north of SIDOR, at a distance of some 400 kms.

It should be noted that part of the gas now used by SIDOR was previously burned off.

3.1.2.3 Electricity: The Caroni River has a large hydro power production potential: the two dams that have been built, Macagua and Raúl Leoni, have the capacity to generate 360 MW and 8200 MW, respectively.

3.1.3 Scrap Iron: This constitutes an essential material in the elaboration of steel; its participation is the most critical in the furnace/oxygen converter/continuous-melt process. It is a scarce material in Venezuela and is therefore usually imported.

C.3.2 Energy Requirements in Steel-making: Table I compares the theoretical requirements for producing steel by means of the different alternatives.

C.3.3 Considerations for the Use of Energy in SIDOR: The operational chart of SIDOR is complicated or complex, combining innovative technologies with obsolete ones, and using large amounts of energy.

Table II shows SIDOR's energy consumption as of 1980.

It can be observed from that table that electricity consumption and natural gas consumption was heavy, while a downward trend could be seen in coke consumption. The efficient use of these resources depends on a continuous, sustained work regimen.

TABLE I

FMO	Sintering	FMO	Pelletization	Direct Reduction – Iron Sponge		FMO	Electric Reducing Furnace	Blast Furnace	Plant and Others		REQUIREMENTS IN PRODUCING 1 METRIC TON OF STEEL			
MIN.	SINT.	MIN.	PELL.	HYL	MID.	MIN.	PIG IRON	PIG IRON	SCRAP	STEEL MILL	ELECT. KWh	NAT. GAS Nm^3	FUEL-OIL Kg.	COKE Kg.
X	40	X	X	60	-	-	45	-	55	SM	1296	473	31	194
X	40	X	X	-	60	-	45	-	55	SM	1334	331	31	186
X	60	-	-	-	-	40	45	-	55	SM	1757	8	31	270
-	-	X	X	60	-	40	45	-	55	SM	1308	465	31	155
-	-	X	X	-	60	40	45	-	55	SM	1278	366	31	154
-	-	X	X	80	-	-	-	-	20	AE	1570	508	-	-
-	-	X	X	-	80	-	-	-	20	AE	1485	375	-	-
X	100	-	-	-	-	-	-	60	40	SM	115	82	31	280
X	100	-	-	-	-	-	-	80	20	BOF	447	8,69	-	425

TABLE II

ENERGY CONSUMPTION IN SIDOR

ENERGY SOURCE	1980	1981	1982
COKE	185,107 tons	161,055 tons	111,276 tons
FUEL OIL	42,000 tons	40,683 tons	35,345 tons
NATURAL GAS			
REDUCTION	447.054,712 nm^3	598,351,000 nm^3	870,700,442 nm^3
REHEATING	493,503,931 nm^3	432,719,822 nm^3	523,248,625 nm^3
ELECTRICITY	3,441,306 MWh	3,356,910 MWh	3,391,859 MWh
RAW STEEL	1,639,094 tons	1,670,239 tons	1,858,256 tons

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Energy Saving in the Japanese Steel Industry

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1. Characteristics of energy consumption in Japan.

Japan has built a highly industrialized society in the 40 years since the war, Japan has become a country which consumes copious amounts of energy. Japanese GNP is about 1,000,000 million US dollars, about 10% of the estimated GNP of the whole world. Energy consumption in 1981 was about 350 million tons of oil equivalent, or 5% of the nearly 6,800 million tons consumed in the world. As is well known, Japan's economic structure depends more heavily on manufacturing industries than those of most other industrialized countries. This is reflected in the breakdown of energy consumption by sector: 58% by industry, 17% by transportation, and 25% by households. Exhibit 1.

Japanese oil equivalent energy consumption per 100 million US dollars of GNP is relatively low among the industrialized countries and these indicate that the structure of the Japanese economy has undergone a transformation focussing on and achieving considerable energy savings. Japan is poor in mineral resources, and used to depend on oil for more than 70% of its primary energy requirements. So the impact of the oil crises on the Japanese economy was very severe indeed. Over the past 10 years efforts have been made to reduce the country's overall energy consumption. Recently, the energy-saving drive has focussed on reducing oil consumption.

If we compare today's oil dependence figure with that before the first oil crisis, we find a reduction of 14%, from 78% in 1973 to about 64% in 1981. This figure, however, is still high when compared to the world average of 42%. So the reduction of oil consumption is a major on-going task for Japan. Exhibit 2-1, 2.

2. Characteristics of the Japanese steel industry's energy consumption

Now, I would like to discuss the energy problems facing the Japanese steel industry.

(1) The steel industry as an energy-intensive industry

At an output of 30 million tons of crude steel a year, Nippon Steel consumes about 5% of all the energy used in Japan in a year and 0.25% of the world's yearly consumption. In view of such large energy consumption, the responsibility of the steel industry to save energy cannot be overemphasized.

Total energy consumption by the world's steel industry is said to account for about 6% of the world's total energy consumption. Therefore, the contribution that the steel industry can make toward solving today's energy problems is considerable.

In 1974 Nippon Steel set targets to reduce energy consumption by 20%: 10% in each of two phases. To date a 17% reduction has been achieved. If it were possible for the steel industry worldwide to reduce energy consumption by 20%, the figure would be about 1% of world energy consumption, which is equivalent to about 70 million tons of oil a year or 1.4 million barrels of oil per day. Exhibit 3.

Another characteristic of the Japanese steel industry's energy consumption is the position of coal as an energy source. In fiscal 1973, a breakdown of the energy consumption showed 61% for coal and coal derivatives, 18% for purchased electricity, and 21% for oil and oil derivatives. In fiscal 1981, these figures were 74% for coal and coal derivatives, 19% for purchased electricity, and 7% for oil and oil derivatives. Coal's share increased by 13% since the first oil crisis. Because of recent efforts to reduce oil dependence, Nippon Steel's fiscal 1981 energy consumption breakdown shows that coal and coal derivatives now account for 87%, purchased electricity 9% and only 4% for oil and oil derivatives. Thus Nippon Steel has established a viable production system with a very low level of oil consumption. Exhibit 4-(1) (2)

(2) Energy saving by the Japanese steel industry before the oil crises

(1) Low blast furnace fuel rate

I mentioned already that the steel industry is an energy intensive industry. Why are such large quantities of energy needed?

In the earth, metallic ores exist normally in the form of oxides. In order to extract metals from these oxide ores, the metals must first be separated from oxygen. This process requires large quantities of energy.

In the ironmaking process, ores are charged into a blast furnace and reduced by coke and oil (mainly by coke) at temperatures as high as 1,600^{o}C. It was said in the past that about one ton of coke-equivalent energy was needed to produce one ton of pig iron. This coke energy is equivalent to the energy in about 1.5 tons of coal. In the steel industry, the reduction of blast furnace fuel rate has long been a major goal. With various improvements made in both operation and equipment, the Japanese steel industry had succeeded in reducing blast furnace fuel rate to around 0.5 ton of coke equivalent by the time of the first oil crisis. This is a good example of what we can achieve through dedicated energy-saving efforts. Exhibit 5.

(2) Minimization of transportation costs

In the steel industry, transportation plays a pivotal role. From the viewpoint of costs, transportation is divided into the following three categories:

(a) Marine transportation of enormous quantities of steelmaking raw materials and fuels from distant overseas sources.

(b) Intra-works transportation through numerous processes from raw materials receipt to shipment of finished products.

(c) Outward transportation of finished steel products to domestic and overseas markets.

Costs of transportation are a very important item for reduction. In order to minimize transportation costs, the Japanese steel industry has concentrated on coastal integrated steelworks.

Viewed from the economy of transportation, a coastal integrated steelworks has the following advantages:

(d) Marine transportation of bulk raw materials and fuels directly to the steelworks and of finished steel products directly from the steelworks to domestic and overseas markets.

(e) Greenfield steelworks allow rational layout of plant and equipment to minimize transportation.

Most of these coastal integrated steelworks in Japan, were constructed before the first oil crisis, and their location and efficient layout of facilities and equipment greatly contributed to the industry's reduction of energy use.

(3) Continuous processes

There is an old saying, "Strike while the iron is hot". The melting and shaping of iron and steel takes place at high temperatures. Hence, if iron is allowed to cool for some reason, a large quantity of energy must be expended to reheat it to high enough temperatures to resume processing. From the viewpoint of steel production, therefore, the ideal process would be a single heat process or a continuous process. To realize this, however, many technical difficulties must be surmounted. These difficulties are focussed on:

(a) Well balanced capacities
(b) Stability of operation
(c) Stability of product quality

Efforts have been made for many years to overcome these difficulties. As a result, remarkable progress has been made in a great number of fields including process continuity, process elimination, improvement of equipment maintenance technology, integrated quality control systems, and integrated control of processes from order receipt to product shipment through the use of computer systems. Even before the oil crisis, process continuity had been realized to a considerable extent.

(4) Efficient utilization of by-product gases

The final area of energy conservation in which the Japanese steel industry had made significant advances before the oil crisis is the utilization of by-product gases. As I explained earlier, because huge amounts of coal are used by the industry, large volumes of by-product gases are generated in the production processes. These by-product gases contain fairly large quantities of energy. Coke oven gas, for example, contains 4,600 kcal/Nm^3 and blast furnace gas contains 700 kcal/NM^3. Steelmakers also supply gases for cooperative electricity generation and to outside electricity generating authorities. Effort has also been made to use these gases as fuels for reheating furnaces and steam boilers. As a result, practically all by-product gases are utilized today.

Thus, even before the first oil crisis the Japanese steel industry had established a fairly advanced energy-efficient production structure, which is one consolation for the industry. Had the first oil crisis occurred in the early 1960s, the Japanese steel industry would have suffered untold hardships, and its very existence might have been in jeopardy.

3. Impact of oil crises and promotion of energy saving

(1) Coping with three problems

The impact of the oil crises on the steel industry was felt first in the form of cost increases.

Secondly, the steel industry entered a long period of shrinking demand. The business climate has continued to be extremely adverse especially since the second oil crisis.

The apparent crude steel consumption by industrial countries was about 430 million tons in 1973 but was 308 million tons in 1982. It is forecast at 314 million tons this year, a level 100 million tons lower than that in 1973. Globally, apparent crude steel consumption was about 700 million tons in 1973. It dropped to 655 million tons in 1982 despite some increases in certain developing nations and communist countries. The projected figure for this year is 667 million tons according to IISI. Thus, it appears that the steel industry will continue to suffer from difficulties for some years to come. Exhibit 6.

This long slump in steel demand also brought about the problem of huge excess production capacity. This excess capacity has forced the industry into low operating rate and, in turn, caused a sharp rise in fixed costs.

Thirdly, changes in the demand structure, accelerated by the oil crises, have forced the Japanese steel industry to shift rapidly from quantity to quality. Accordingly, the industry has faced keen competition in the development of higher quality products.

For the past decade the steel industry has been trying to cope with these three problems.

(2) Energy saving

Faced with the oil crisis, the Japanese steel industry decided to deploy manpower and funds to energy-saving projects.

While the specific energy consumption per ton of crude steel was 5.41 Gcal in fiscal 1973, when total crude steel production was 120 million tons, it was reduced to 5 Gcal in fiscal 1981, when total crude steel production was 103 million tons. More precisely, after adjustment of consumption based on the operating conditions of 1973, the specific energy consumption figure becomes 4.64 Gcal for fiscal 1981. This figure shows a level about 14% lower than attained 8 years ago. If these figures are added up, the cumulative energy savings would amount to 36 million kl of oil equivalent. Also, the consumption of oil and oil derivatives was 15.5 million kl in fiscal 1973, but was brought down to 4.3 million kl in fiscal 1981, a reduction of about 70%. Exhibit 7.

4. Energy-saving management systems in Nippon Steel

Next, I would like to describe how such energy-saving projects were promoted and managed.

(1) Setting corporate targets

First, ambitious corporate targets were set and informed to all employees. Then, they were broken down for individual plants and mills by the plants concerned.

(2) Management system established for the saving of energy

In addition to the conventional general management systems for controlling budgets, costs, technology, etc., a new general management system for controlling energy use was established to enhance the organizational and administrative aspects of energy-savings.

(3) Training

Many people were trained in energy-saving technology and became expert in this field. This group of experts carried out not only the analysis of complex energy consumption characteristics but also cooperated with plant and mill personnel in systematically identifying a large number of areas where energy could be saved.

(4) Integrated energy demand-supply management

The computer-aided energy demand-supply Information Control and Management Center was reinforced for integrated and detailed control of energy demand and supply.

These four systems have been very effective in promoting energy-savings. In the application of these systems, however, the development and introduction of measuring equipment and sensors for the accurate detection and understanding of complex energy flows have played an exceptionally important role in the advancement of technology for energy analysis.

5. Energy-saving methods and their effects

Now, I would like to examine the various methods of saving energy and their effectiveness.

(1) Improvement of ooerating methods

The first energy-saving efforts were directed at improvement of operating methods. A reduction in energy losses from daily operation was sought by changing operating conditions to those designed to maximize energy efficiency, in order to eliminate energy waste. Improvement of operating methods required little investment, but promptly produced significant energy savings. Naturally, in order to succeed, this method requires constant technical studies by superintendents and technical staff. And in this study the Japanese steel industry was greatly aided by the self-motivated improvement activities called Jishu Kanri or J-K activities.

(2) Selective investments in energy-saving equipment and facilities

The second method of saving energy was through the promotion of investments in energy-saving equipment and facilities. With the sharp increase in energy prices, the profitability of some equipment investment proposals which used to be considered low rose substantially. Hence, all technically possible actions in all processes were studied. And a very stringent standard was formulated to assess the economics of each possible investment.

The business climate was so depressed that no increase in production capacity was sought, instead, temporary equipment shutdowns were considered. The investment recovery periods were finally set at 1 - 2 years for small-scale investments and 2 - 3 years for large-scale investments. In order to meet these standards, extensive efforts were made to develop new equipment technology. Thus, we believe we have made some very efficient energy-saving equipment investments.

These equipment investments cover a wide range from relatively small-scale investment in automatic combustion control systems for reheating furnaces to large-scale investments in power generating equipment run by the energy of recovered sensible heat of hot coke. At Nippon Steel alone, there were 1,000 large investment items in 150 different fields, requiring a total investment in excess of 100,000 million yen (about US$400 million). The total amount invested by the Japanese steel industry as a whole is estimated to be over 300,000 million yen (about US$1,200 million).

(3) Rationalization and modernization of large-scale equipment and facilities

The third method of energy-saving is extensive rationalization and modernization of equipment, or the replacement of obsolete equipment. Because investments for these purposes were directed primarily toward achieving improvements in productivity, product quality, and costs, many new technologies were incoroporated in the equipment for which investments were made. These investments yielded additional benefits in the form of energy-savings. For example, large energy savings have been realized by investments in the continuous casting process, the continuous annealing process, development of advanced galvanizing processes, and the replacement of steelmaking plant equipment, hot and cold rolling mill equipment, etc.

(4) Major technologies that contributed to energy-saving

Now, I would like to mention briefly those technologies that have contributed most to energy-saving.

Technologies employed for reducing specific fuel consumption of blast furnaces, recovery of converter waste-gas, improvement of electric arc furnace operation, development of the continuous casting process, improvement of reheating furnace operation in hot rolling mills, and recovery of various kinds of waste heat produced about 90% of all energy-savings over the past 8 years. Exhibit 8.

(5) Shift of emphasis on energy-saving methods

As we review the energy-saving measures adopted over these 8 years, some characteristic changes can be noticed.

The emphasis on energy-saving measures gradually shifted from the improvement of operating technology to the improvement of equipment technology. The contribution to energy-savings made by improvements in operating technology was 55% in the first 5 years, but decreased to 13% in the last 3 years.

The weight of waste-gas recovery in energy-savings has been gradually increasing in recent years through various equipment measures. While waste-gas accounted for only 13% of all energy-saving investment in the initial years, its contribution has now reached more than 80%.

As is clear from the foregoing, the economics of investments in energy-saving equipment have been worsening each year. Viewed from a different angle, however, this might be understood to mean that continued energy-price increases over the years have necessitated investments in an increasingly wider range of items. At any rate, we must continue our efforts to develop technologies for improving the efficiency of energy usage. Exhibit 9.

6. Measures to reduce oil consumption

I would like to examine some measures that have been adopted to reduce oil consumption.

The difference in price between oil and coal was widened by the second oil crisis. Therefore, measures to reduce oil consumption are very important today.

A typical practice in this respect is the all coke operation of blast furnaces. Conventionally, heavy oil was used in blast furnace operation for about 10% of all blast furnace fuel. All of this heavy oil was replaced by coke in an attempt to lessen the industry's dependence on oil. Although this replacement of oil with coal somewhat increased the total energy required to produce steel, it has brought about a significant cost advantage.

Presently, most blast furnaces in Japan are fueled by coke, and new operating techniques such as tar injection and pulverized coal injecton have been adopted in recent years.

The increase in the quantity of coke used in blast furnace operation increases the volume of by-product gases produced. This by-product gas can be utilized in various processes to replace petroleum fuels, and this has had the effect of reducing oil consumption even further. As a result, oil and oil derivatives consumption by the Japanese steel industry has decreased substantially to about 4 million kl, only about 1.5% of the total heavy oil consumed in Japan.

7. Outlook for energy-saving

(1) As the last topic of my address today, I would like to touch briefly on the outlook for further energy-savings by the Japanese steel industry.

As mentioned earlier, steel demand outlook is not too bright. Japanese crude steel production will continue at about 100 million tons for some years to come. Hence, old and inefficient equipment and facilities will be closed down or replaced. It can be assumed, therefore, that cost-competitive integrated steelworks and steelworks based on small-scale but efficient electric arc furnaces with distinctive features of their own will probably survive.

It is also certain that energy-saving technologies will advance. Taking all these into account, it is possible that energy consumption per ton of crude steel produced by the Japanese steel industry may further decline from the current level by up to 10%.

(2) Waste-heat recovery

To realize this, the development of new energy-saving technologies, especially those for waste heat recovery, needs to be further encouraged, and active invesments will be necessary. It is widely understood that approximately 40% of energy consumed in iron- and steelmaking is lost in the form of waste heat, and only a small percentage of this waste heat is currently being recovered. Huge investments will be required to recover all waste heat, but such recovery is not possible yet given the present state of the art. Yet, the low level of present recovery needs to be improved. In this respect, further technical development is earnestly needed. Exhibit 10.

Thus, because unresolved difficult problems are involved in attaining a further 10% reduction in energy consumption, five or more years may be necessary to realize this target.

(3) Energy-efficient integrated steelworks

What needs to be pointed out at this juncture is that if and when this additional 10% reduction in energy consumption is realized, the only primary energy to be purchased by an integrated steelworks will be coal. Naturally, no heavy oil consumption will be necessary. In addition, the electricity required can all be generated by utilizing by-product gases or recovered energy.

Then, the next stage will come where surplus energy will be generated and sold outside the steelworks. Although even today some energy is sold to outside users by Nippon Steel in the form of gas for electricity generation etc., what is envisaged, are new forms of energy made possible by the development of coal chemistry. Nippon Steel has been separating light oil, middle distillate, pitch, tar, ethylene, hydrogen, etc., from coal tar and gas from coke ovens, producing and selling various chemicals made from them. Nippon Steel is now working on so-called C_1 chemistry, i.e., the synthesis of CO and hydrogen as raw materials for building basic chemicals as a technical extension of coal chemistry.

(4) Expansion of coal utilization technologies

Compared to oil reserves, coal reserves are plentiful and widely distributed all over the world. Hence, a comparatively stable supply of coal can be expected.

Past experience, however, has shown us that if the oil demand-supply balance is disturbed, the coal demand-supply balance is also affected. The steel industry is the industry which can use coal most efficiently. For this reason, the industry is always eager to secure stable supplies of coal. At the same time, the industry needs to expand the range of usable coals to give it greater freedom in the choice of types of coal.

The steel industry has been actively engaged in the research, development and commercialization of the technology for formed coke manufacturing, and technology for pulverized coal injection into blast furnaces. Also technological development for non-coking coal or poor coking coal utilization aimed at freeing the industry from reliance on coking coal is underway.

(5) Importance of scrap utilization

Another subject which should not be overlooked in connection with energy-saving is the utilization of scrap. Scrap is an important iron resource which, when used in steel production, can contribute to energy-saving.

Investments in social overhead capital and equipment investments in the private sector increased rapidly in industrialized countries through the 1960s, and, as a result, the accumulation of iron and steel has increased greatly in these countries.

In addition, the production of durable consumer goods such as automobiles and electric appliances has reached a very high level in recent years. The quantity of scrap generated in industrialized countries is increasing each year. However, since iron and steel production cannot be expected to rise in the foreseeable future, it is reasonable to assume that the scrap demand-supply situation will continue to be slack for some years. Accordingly, the scrap utilization ratio by the steel industry will probably increase gradually, and the increase in scrap consumption will have the effect of contributing to energy conservation.

8. Conclusion

(1) I have mentioned the energy-saving activities of the Japanese steel industry.

Many years of strenuous efforts by the industry to improve its technical standing in order to manufacture better quality and lower cost products have resulted in great energy-savings. The three problems I outlined earlier that face the industry have led to technical innovations in various fields which have enabled the improvement of labour productivity, the reduction of specific consumption of energy and raw materials, the improvement of various yields at different stages of iron and steel production, the development of high quality materials, the establishment of a fixed cost structure viable at low operating levels, and so forth.

Nevertheless, energy is undoubtedly a subject which will require constant attention from industrial societies and the steel industry in particular.

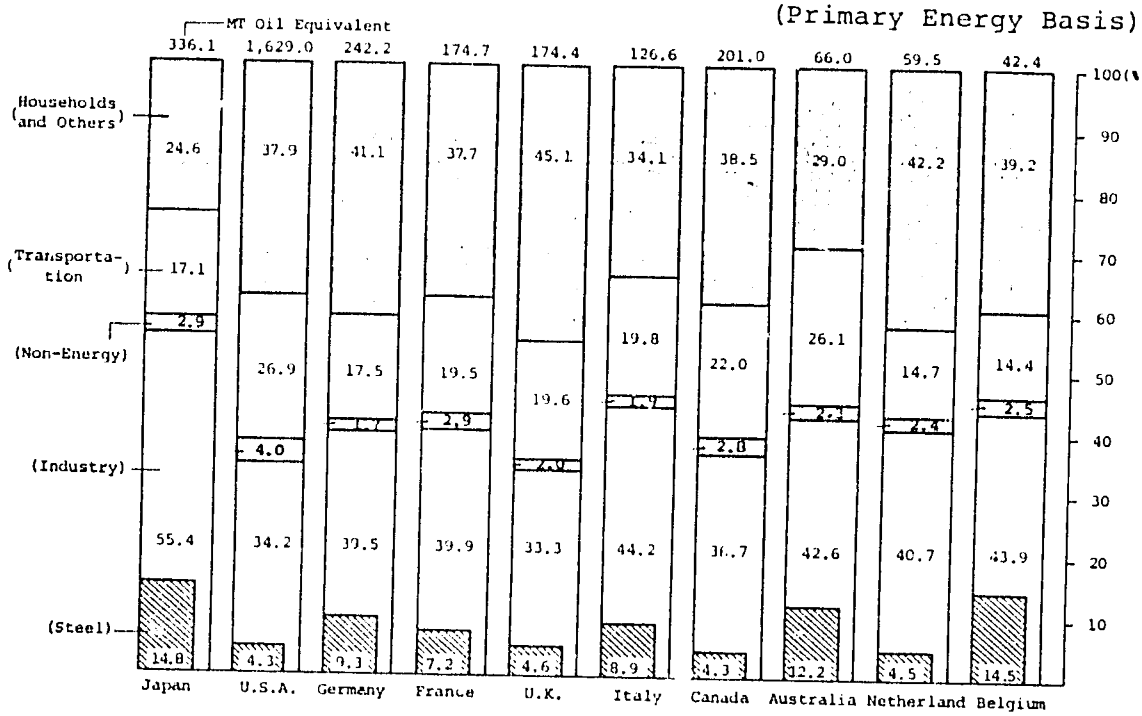
(2) Energy problems will certainly have a large influence on the future of the steel industry. Steel demands in developing countries are expected to grow. The supply of steel products to meet this growth will depend on the internal demand for iron and steel or energy conditions. If they are unfavourable for domestic production, it might be advantageous to import iron and steel products or semi-products. If, however, hydro-electric power or natural gas is available at low cost, it may be suitable for these countries to adopt a production system, perhaps the so-called mini-mill system coupling a direct reduction facility and the electric arc furnace processes.

The integrated steelworks with blast-furnace iron-making as its chief process, described earlier, will undoubtedly continue to be the main stream. It should be remembered, however, that this production system required huge investments. Also, steelworks based on new processes such as nuclear steelmaking may come into being in the future. Much progress can still be expected in iron and steel manufacturing technologies.

It should be realized, however, as I have been repeatedly pointing out, that the future of the steel industry will be extremely tough. So, in concluding my address, I would like to repeat, "Strike while the iron is hot".

Exhibit 1. Total Final Energy Consumption by Sectors 1980.

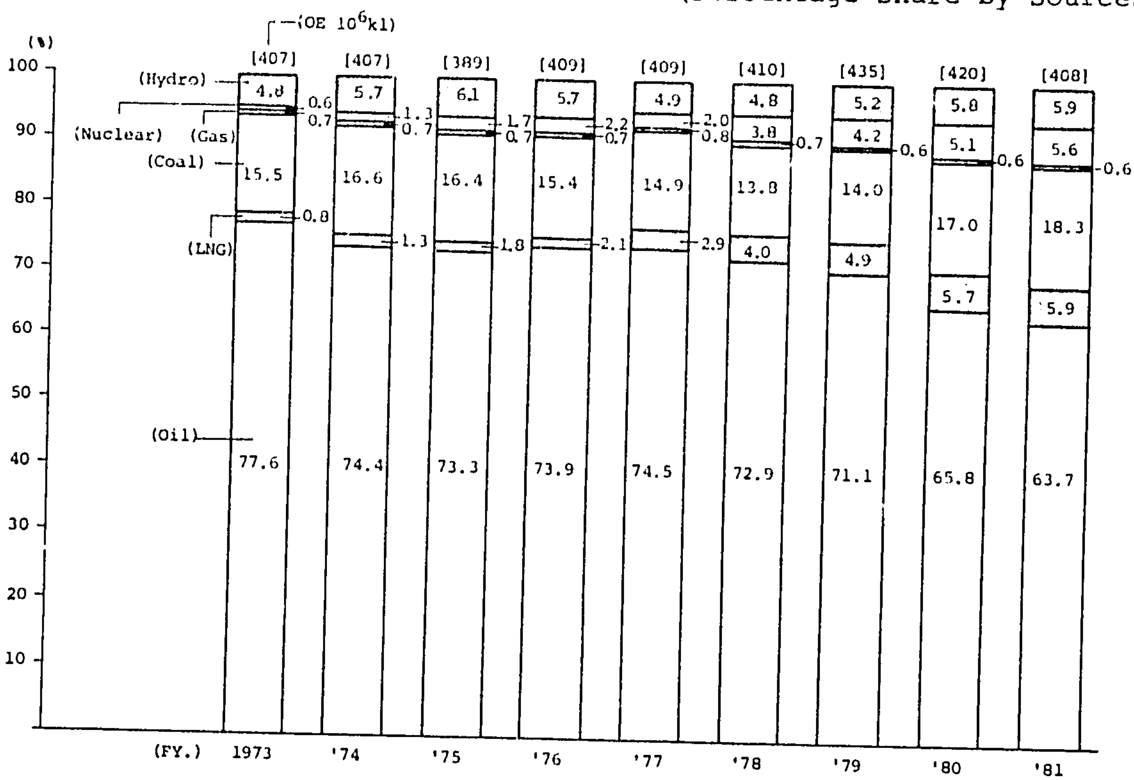
(Primary Energy Basis)



Source: OECD Energy Balances

Exhibit 2-① Primary Energy Demand of Japan

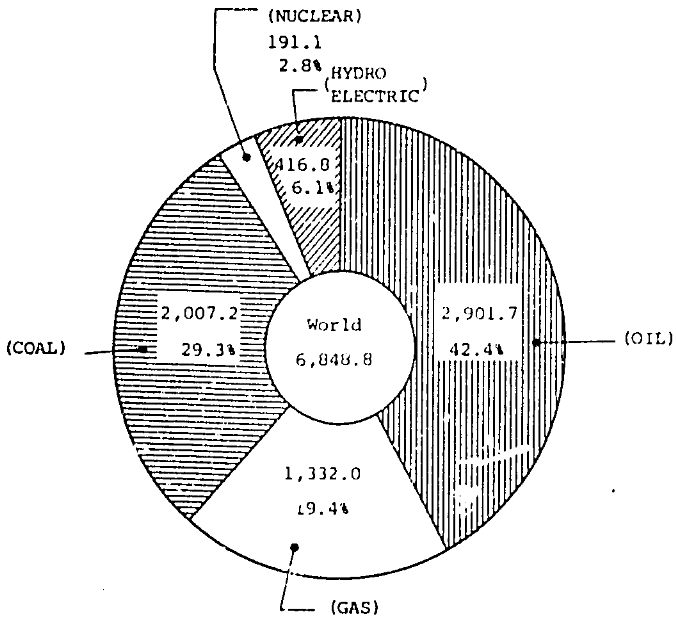
(Percentage Share by Sources)



Source: Energy Statistics of Japan (1982)

Exhibit 2-② . Primary Energy Demand of the World [CY. 1981]

(Unit: MTOE)



Source: BP STATISTICAL 1981

Exhibit 3. Changes in Energy-saving Measures (NSC)

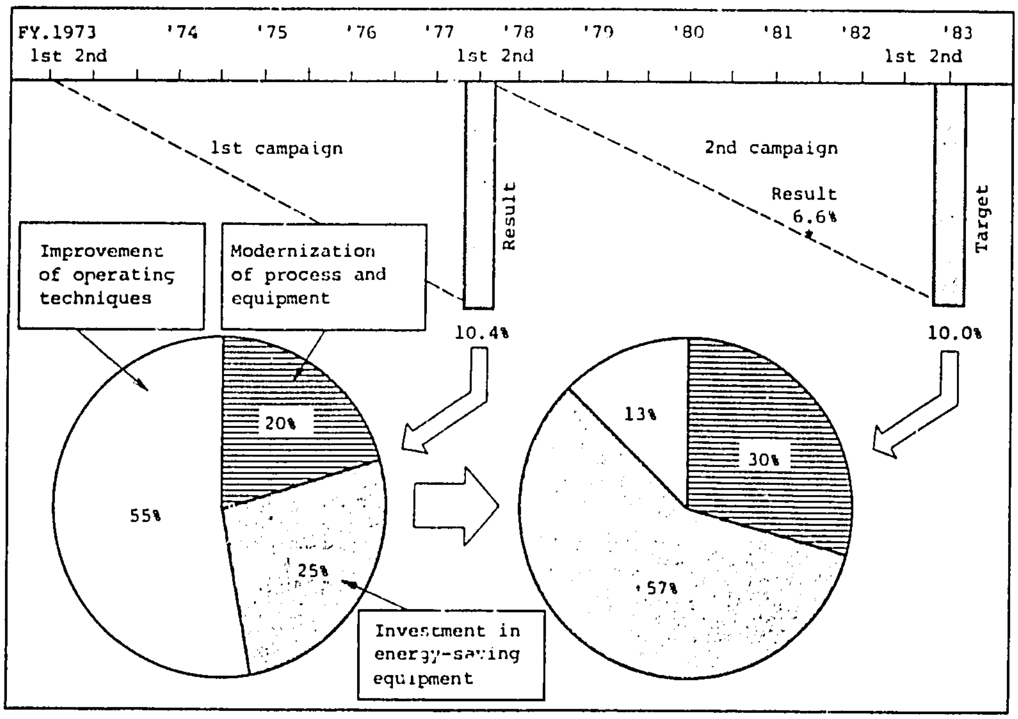


Exhibit 4-① Energy Consumption by Japanese Steel Industry

[Unit: Pcal (10^{12} Kcal)]

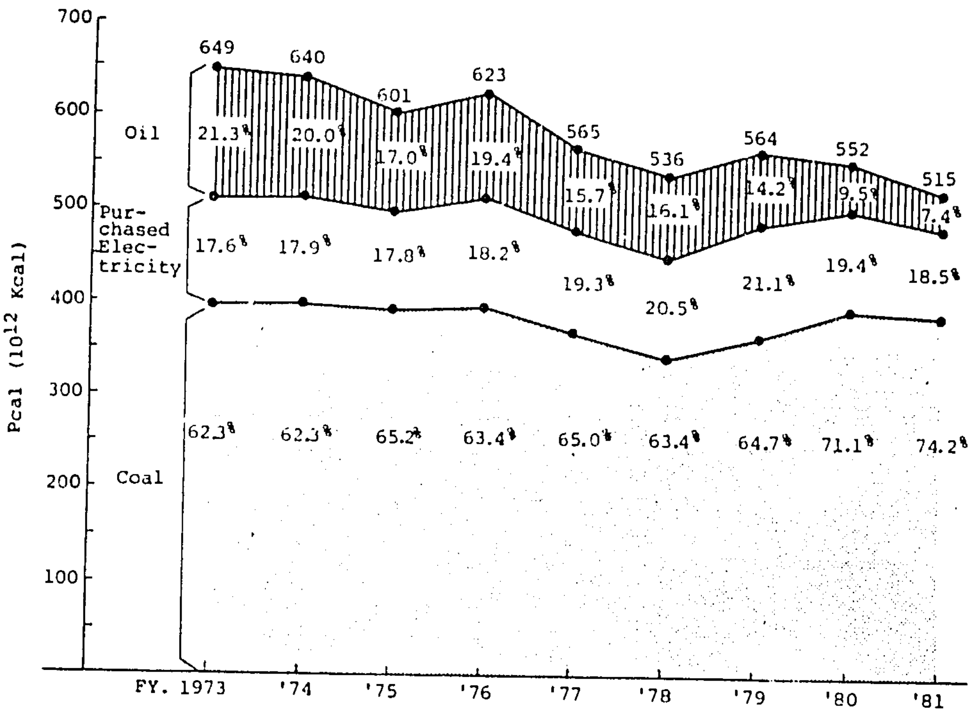
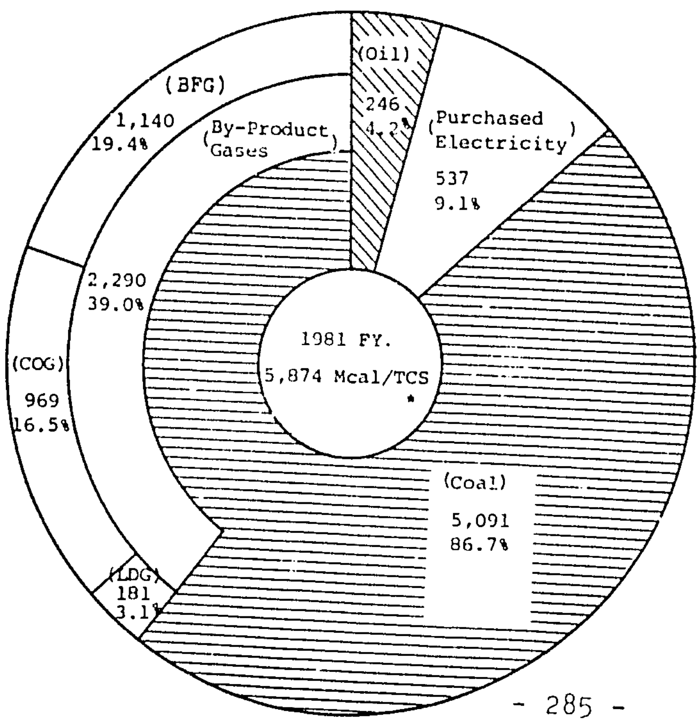


Exhibit 4-② Pattern of Energy Consumption (NSC)

[Utilization of By-Product Gases]

(Unit: Mcal/TCS)



* Ton/crude steel

Exhibit 5. Progress of Ironmaking Technology in Japan

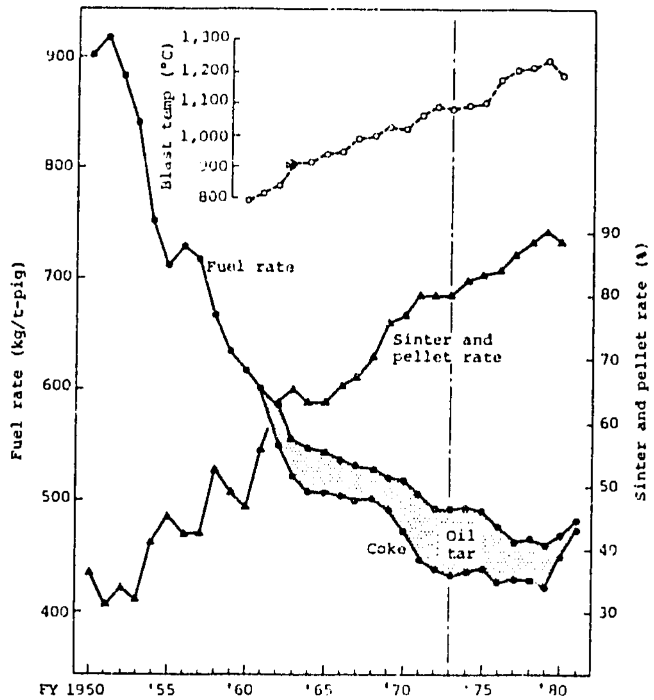
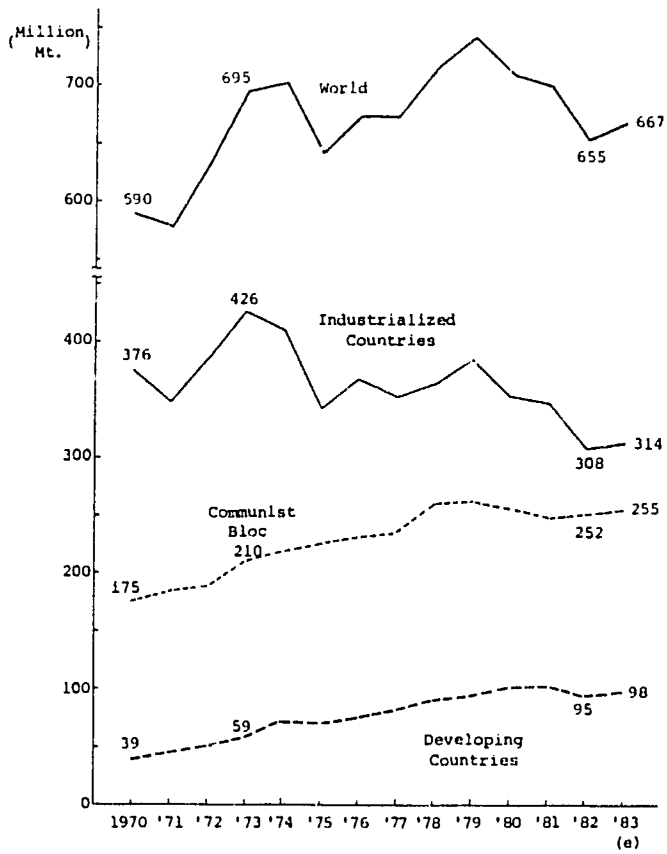


Exhibit 6. World Apparent Crude Steel Consumption



Source : IISI

Exhibit 7. Energy-saving Results and Oil Consumption in Japanese Steel Industry

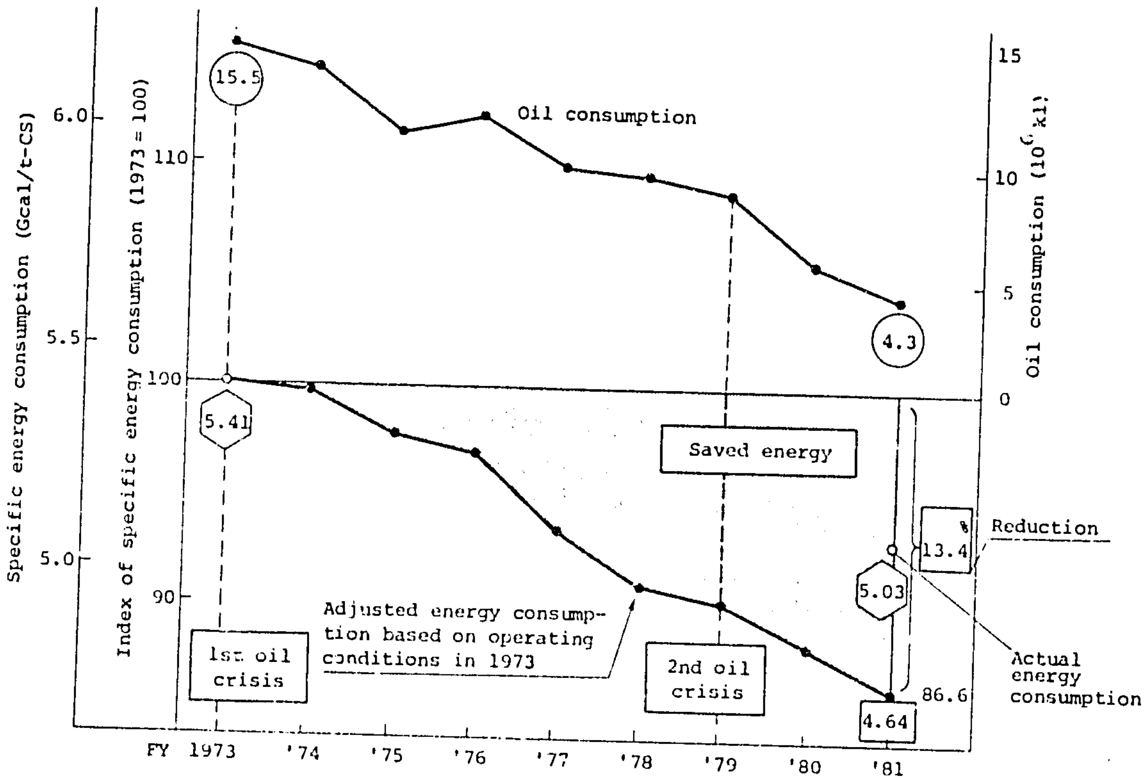
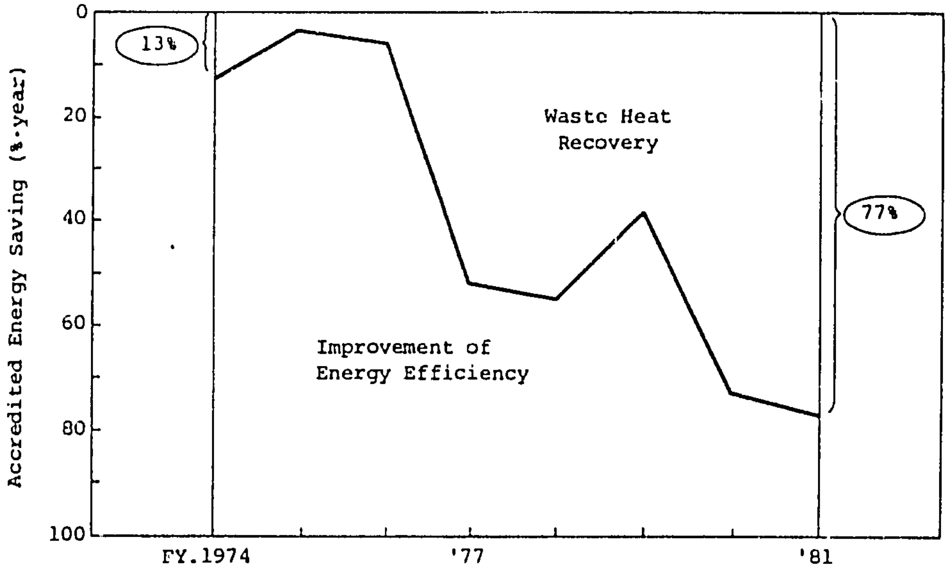


Exhibit 8. Effect of Typical Energy-Related Factors (Japan)

	Factor	Unit	FY. 1973	FY. 1981 (E)	Difference	Effect Mcal/tcs	Effect Energy-saving rate (%)
A	Fuel Rate at BF (Injectant)	kg/t-pig	498 (58)	486 (8)	12 (50)	85*	1.6
B	BOF Gas Recovery Rate	m^3N/tcs-BOF	25	85	60	90	1.7
C	Electric Power Consumption at EAF	kWh/tcs-EAF	537	467	70	40	0.7
D	CC Ratio	%	21	73	52	100	1.8
E	Fuel Consumption at R. Furnaces	Mcal/t -stock	530	320	210	200	3.6
F	Waste Heat Recovery	%	–	2.6	2.6	140	2.6
Sub-total						655	12.0
Total						730	13.4

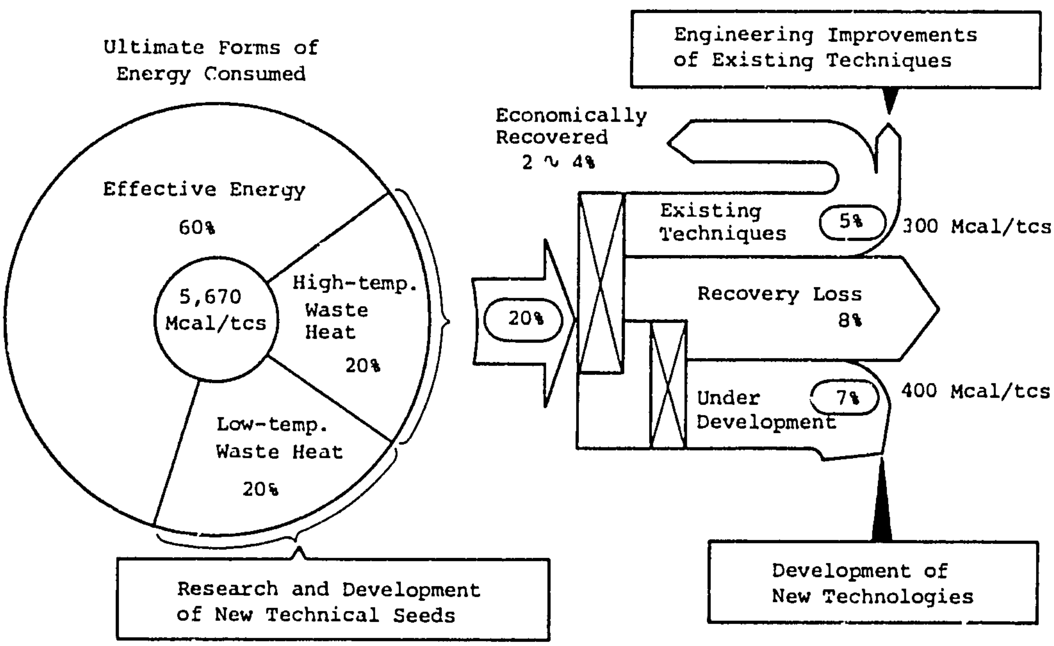
Note: * Effect at BF with BF operating conditions taken into account

Exhibit 9. Purposes of Investment for Energy-Saving Equipment (NSC)



Note: Investment amount: approx. 100 billion yen
No. of projects : approx. 1,000

Exhibit 10. Waste Heat Recovery at Integrated Steelworks (NSC)



RATIONAL ENERGY USE IN BRAZIL'S IRON AND STEEL INDUSTRY

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(COSIPA)

1. INTRODUCTION

We feel that the topic before us is, and will long remain, extremely important and timely now that the energy problem has, in the modern world, added to its economic nature a heavily strategic component.

The exchange of experiences fostered by this initiative of OLADE will certainly bear fruit, since everything that we do in our lives may always be imporved and the exercise of reason is an inherent characteristic of mankind.

In view of the fact that the select public present here is not confined exclusively to the iron and steel industry, we shall endeavor to introduce you, gradually and in laymen's terms, to this industrial sector, to enable you to better understand the actions that ave been planned and executed, and their results.

2. THE IRON AND STEEL INDUSTRY'S SHARE IN TOTAL PRIMARY ENERGY CONSUMPTION IN BRAZIL

We believe that it is necessary to begin by identifying the iron and steel industry's share in the country's energy consumption, to thereby afford a fair, complete notion of its significance and enable you to grasp its importance and influence in the country's economy.

In 1980 the item of Pig Iron and Steel consumed 6 percent of all the petroleum used for fuel in Brazil and was responsible for 7.2 percent of the country's electrical consumption.

In Figure 1, we can see the participation of the different energy sources in Brazilian iron and steel manufacture during that same year (1980):

Coal, 46,3%
Electricity, 22.8%
Charcoal, 16,6%
Fuel Oil, 11.4%
Coke, 1.6%
Natural gas, 1.3%

These data must be examined in light of the way in which those energy sources are utilized in steelworks.

3. ENERGY FLOW IN STEELWORKS

To better understand the actions that have been executed, it is indispensable that we all be familiar with the way that the energy flow is processed in our steelwork; and in this case, because of the ease in obtaining the corresponding data in the Siderbrás group steelworks, we shall focus on that group.

To make it easier to analyze, we shall divide steelworks into two large sub-groups: "non-coke" and "coke".

Figure 2 shows the energy flow of the non-coke steelworks of the Siderbrás system, comprising the following companies:

Usina Siderúrgica de Bahia - USIBA
Companhia Siderúrgica de Mogi das Cruzes - COSIM
Acos Finos Piratini - A.F.P.
Companhia de Ferro e Aco de Vitória - COFAVI

Of the above, the only one that has no reduction area is COFAVI, whose flow begins in the steel mill; while the rest use direct reduction starting with natural gas: the Hylsa process (USIBA), direct reduction starting with coal, the SL/RN process (Acos Finos Piratini); and a integrated plant using charcoal (COSIM).

We can note a great heterogeneity in this group, due to regional energy use approaches; however, this constitutes greatest stumbling-block for the eliminiation of fuel oil.

The high degree of doemestic energy source usage is also worthy of note.

Figure 3 shows the "coke" steelworks group of the Siderbrás system.

Here, coal enters the steelworks through the coke oven, since coal is not mechanically strong enough to withstand the weight of the load inside the blast furnace.

In the coke oven, coal undergoes fractional distillation which extracts its volatile substances, producing a porous product known as "coke", which is mechanically strong enough to the weight in the blast furnace.

The volatile substances extracted from the coal undergo a process of chemical cleaning that extracts the cokeworks' by-productos: toluene, benzole, xylene, naphtha, and benzene. Aside from these, after the chemical cleaning of the volatile substances, a combustible gasesous product is obtained and recycled to heat the furnaces.

This gaseous mixture is called "coke gas".

The coal, now in the form of coke, goes on to the blast furnace to supply the energy and reduced necessary to obtain pig iron.

Air injected through nozzles combines with the carbon in the coke, forming carbon monozide, which reduces the iron ore: other gaseous forms are obtained from the reaction of the CO with carbon, giving off CO_2.

Moreoever, the water that enters the furnace, as moisture, breaks down into hydrogen and oxygen and mixes with the nitrogen in the air. Finally, that gasesous mixture, not having a reaction efficiency of 100%, rises to the top of the blast furnace, thereby becoming another combustible gaseous mixture, used internally for general heating.

That gaseous mixture is calles blast furnace gas. To be usable, it must be physically cleaned of the particles that is contains.

The complementary need for heating fuel is met with fuel oil, the consumption of which is reduced by recycling these two by-product fuels, coke gas and blast furnace gas.

4. BANKING OF PRIORITIES

As a first step in reducing energy consumption, the following order of priorities was established:

I. Reduction of consumption of fuel oil
II. Reduction of consumption of imported coal
III. Reduction of consumption of electricity

The first two items on this list of priorities are ranked first for obvious reasons.

The reduction of electrical consumption comes third because we have abundant, low-cost hydroelectric energy.

The latest major accomplishment in this sector was the completion of the dam for the Itaipú hydroelectric power plant, which I believe that you have all heard about. When this plant reaches full capacity, it will produce energy equivalent to 500,000 barrels/day.

5. STRATEGY

The following strategy was adopted:

I. Elimination of waste
II. Improvement in the efficiency of equipment
III. New, more energy-efficient projects

In order to clear up any doubts and better understand the intention of these goals, we should like to explain that the first two goals include all actions that tend toward more rational energy use without additional investment, or with negligible investment.

The third item includes all those actions that imply large-scale changes in projects and therefore, call for significant investments.

We may affirm that, with very few exceptions, this last item has not been implemented.

6. ACTIONS AND RESULTS

Of all the actions that have been executed, we shall select those that really stand out, whether because of the principle involved (as they must be rational) or because of their quantitative results in energy consumption reduction.

We shall subdivide this item into two groups for the sake of convenience in presentation, and because the characteristics of the two groups do differ.

6.1 Steelworks in the private sector

- Elimination of losses
- Elimination of consumption points
- Improvement in thermal efficiency of existing equipment
- Substitution of blast furnace gas for fuel oil consumption points
- Loading of hot pigs
- Adjustment of furnaces
- Enrichment of the oxygen in combustion air
- Use of the submerged blow process in Siemens Martin furnaces

I feel it would be interesting to elaborate a bit on this last action.

With this process, a 75% reduction in fuel oil consumption is obtained. This means that a Siemens Martin* furnace modified to use this process will consume a yearly average of only 25% of the fuel oil that it consumed before the modification.

Another extremely important characteristic is that productivity is increased by 100%.

These data are contained in a paper presented in the ILAFA Energy Congress held in Rio de Janeiro in 1981.

The steelworks in this sector can be subdivided into two groups:

- group B comprises the charcoal-using integrated steelworks (a plant is said to be "integrated" when its units allow the complete processing of the finished product, beginning with iron ore).
- group C comprises the semi-integrated steelworks or those processing scrap iron.

The results obtained are given in Table 1, in which we can see that during three years group B surpassed the commitment that it had adopted with the Federal Government as a short-term goal, reducing the 1978 specific consumption of 118 kg/t to 66.5 kg/t in June 1981, a 43.6% reduction.

The group C steelworks reduced their 1978 specific consumption of 93.1 kg/t to 67.9 kg/t in June 1981, a 27.1% decrease.

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* open-hearth

6.2 Steelworks in the state sector - SIDERBRAS

. Elimination of Losses

This is a highly important action.

First of all a way was sought to reduce losses, which represent totally unnecessary consumption without any benefit to the production process.

This elimination process was applied to all the fluid utilized in the steelworks.

For example, one reduced its consumption of steam by 10% when it managed to eliminate losses along its piping and systems.

. Personnel Consciousness-Raising

It has been necessary to undertake large-scale compaigns to achieve motivation within these firms, at all levels, with an eye to reducing energy consumption.

. Specific Training for Operators

All operators have been briefed as to how they should perform in order to achieve the greatest efficiency with the equipment that they are responsible for.

Furthermore, to motivate the operators, a sort of fuel/energy-consumption-monitoring internal championship was held so that each operator would vie with those of the other shifts to see who could save the most.

- Improvement of Combustion Efficiency through adjustment of the furnaces

This was an activity the incentives for which increased in intensity through analyses of effluent gases in the smokestacks, which provided the indications necessary for adjusting the stoichiometric fuel/air ratio in the furnaces.

- Monitoring of Demand, Power Factor, and Load Factor

This item is mainly aimed at lowering the electricity bill.

- Effective Maintenance of Thermal Insulation

This action was imperative because it involved energy losses, both in the furnaces and in the steam lines.

- Equipment Efficiency Improvement

This has been achieved through a constant, redoubled maintenance effort.

Obviously well-maintained equipment performs much better than equipment in poor operating condition.

- Improvement in Furnace Heat Insulation

In all necessary furnace insulation changes, the original fireproofing plans were restudied and the most technically and economically advisable decisions made.

. Substitution of Electricity for Petroleum Derivatives

As an example, we might mention the substitution of electric motors for blower turbines in blast furnaces.

. Improved Furnace Utilization

Two examples of the attempt to load furnaces up to or--wherever possible--beyond their rated capacity were 1) the increase in the tonnage per run in the steelworks, designed so as to reach the full capacity of the ingot reheating furnaces, and 2) the increase in plate lengths, which also increased the loading of the plate reheating furnaces.

. Increased Oxygen Injection in Blast Furnaces

This action has been accompanied by an increase in the fuel oil injection in such a way as to improve the blast furnace's efficiency, thereby achieving a lower fuel rate.

This practice was later eliminated in view of high fuel oil prices and decreased production due to marketing difficulties.

Figure 4 portrays the reversion of imported coals and fuel oil prices which occurred in Brazil.

. Automatic Analysis of Flue Gases

- Adoption of External Desulphuration of Pig Iron

All the coke-using steelworks adopted this process.

- Substitution of Oxygen Converters for Reverberatory Furnaces in Steel Production

Figure 5 shows the evolution of the participation of the different steel-making processes in Brazil.

Beginning in 1975, when the LD process was introduced into the country, it increasingly supplanted the open-hearth process, which has a large fuel oil consumption.

The LD process is advantageous in any country because of its high productivity, and more so in Brazil, where that advantage is enhanced by virtue of the use of a domestically-produced energy source, electricity "via oxygen".

Figure 6 shows the participation of the diverse processes in Brazilian steel production in 1980.

- Adoption of the Continuous Ingot-Molding equipment that it replaces and likewise uses only electricity, thereby eliminating all the fuel oil consumption.

Figure 7 shows the evolution of the percentage of national steel production used by this process.

. <u>Gas Recovery from the LD Steelworks</u>

Of the three existing coke-using steelworks, two recover this gas.

. <u>Implementation of energy use and distribution of monitoring systems</u>

This consists of the purchase and installation of consumption-measuring instruments that have been placed at the important points that had hitherto had no measurement capability or where the instrumentation had, through long use, become inoperative.

Depending upon the complexity of the energy set-up, computerization may yield great benefits. There is one plant in the Siderbrás group that owns two computers for its energy flow monitoring.

Although there have been quite a few actions that we have not mentioned, we feel that the measures described in this paper have been the most representative and significant.

The specific overall consumption of primary energy sources is commonly accepted, among other indexes, as a point of reference for energy efficiency in the iron and steel industry.

Figure 8 shows the evolution of this indicator.

Given that this figure was 100 in 1976 and that it dropped to 75.2 by 1980, a decrease of nearly 25% occurred during this period.

Figure 9 reveals that, although liquid steel production has more than doubled, the consumption of fuel oil used as a heat source was curtailed in real terms by 34.1%.

7. FINAL CONSIDERATIONS

Energy conservation is the cheapest, most efficient, and fastest way to accomplish a reduction in energy consumption. Moreover, it is a powerful personnel motivation factor, as reflected in significant results, rewarding the creativity of its originators with professional satisfaction.

Petroleum will remain unstable due to centuries-old political and ideological differences.

Oil prices will doubtlessly soar again in the not-so-distant future.

It has already been said that "the cheapest barrel of oil is the one that we don't waste".

For those countries that do not import petroleum, rational energy use holds the advantage of increasing reserves, which is much less expensive than exploring and producing from new reserves.

For countries that import petroleum, rational energy use is mandatory, in view of not only the financial and currency exchanges factors, but also the highly important strategic component.

The energy question is above all managerial. If it were otherwise, it would be impossible to fathom how Japan, despite its own lack of petroleum, passed unscathed through the tempest that shook the world

In energy management, planning is especially important.

Planning must be flexible enough to adapt to junctural developments.

There are no cure-alls in the energy sector, which is why planning must be adaptable to the needs of each user.

Although at the moment there is a generalized inability to invest, it is advisable to use this time to prepare plans that may be applied when the situation allows.

Henceforth, more than ever before, the energy issue will be on the list of priorities for those who guide the world's trajectory.

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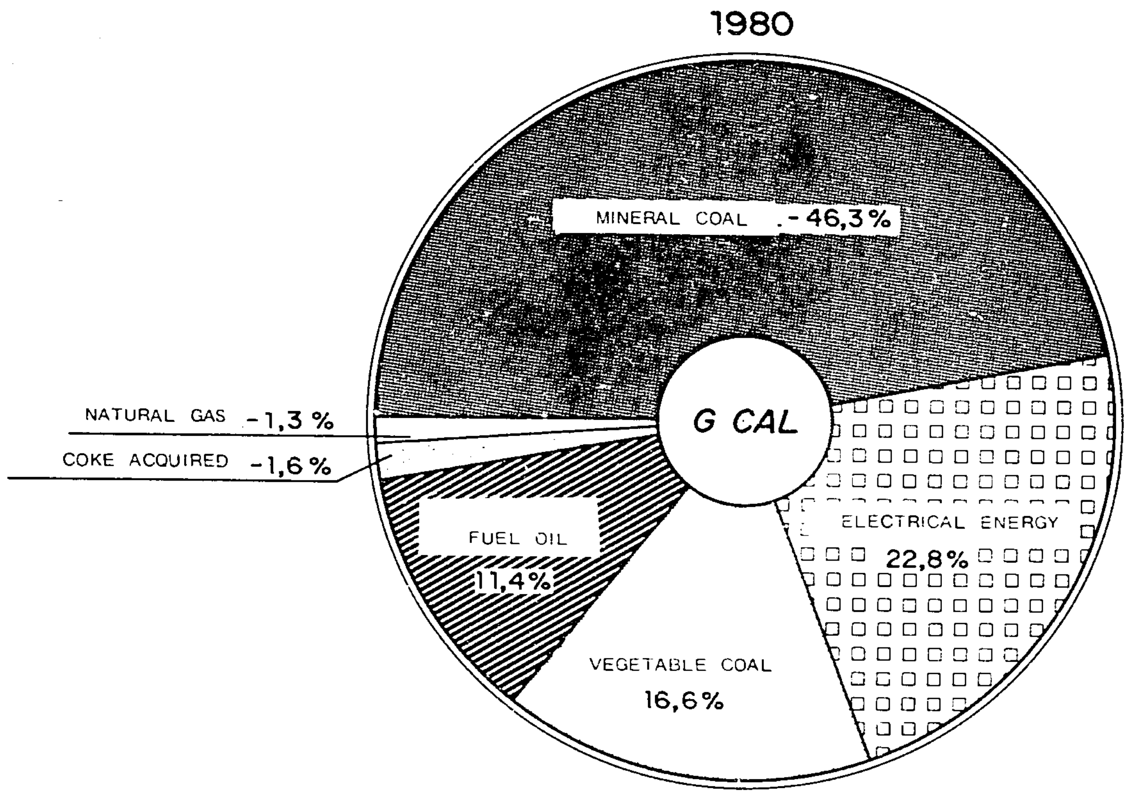

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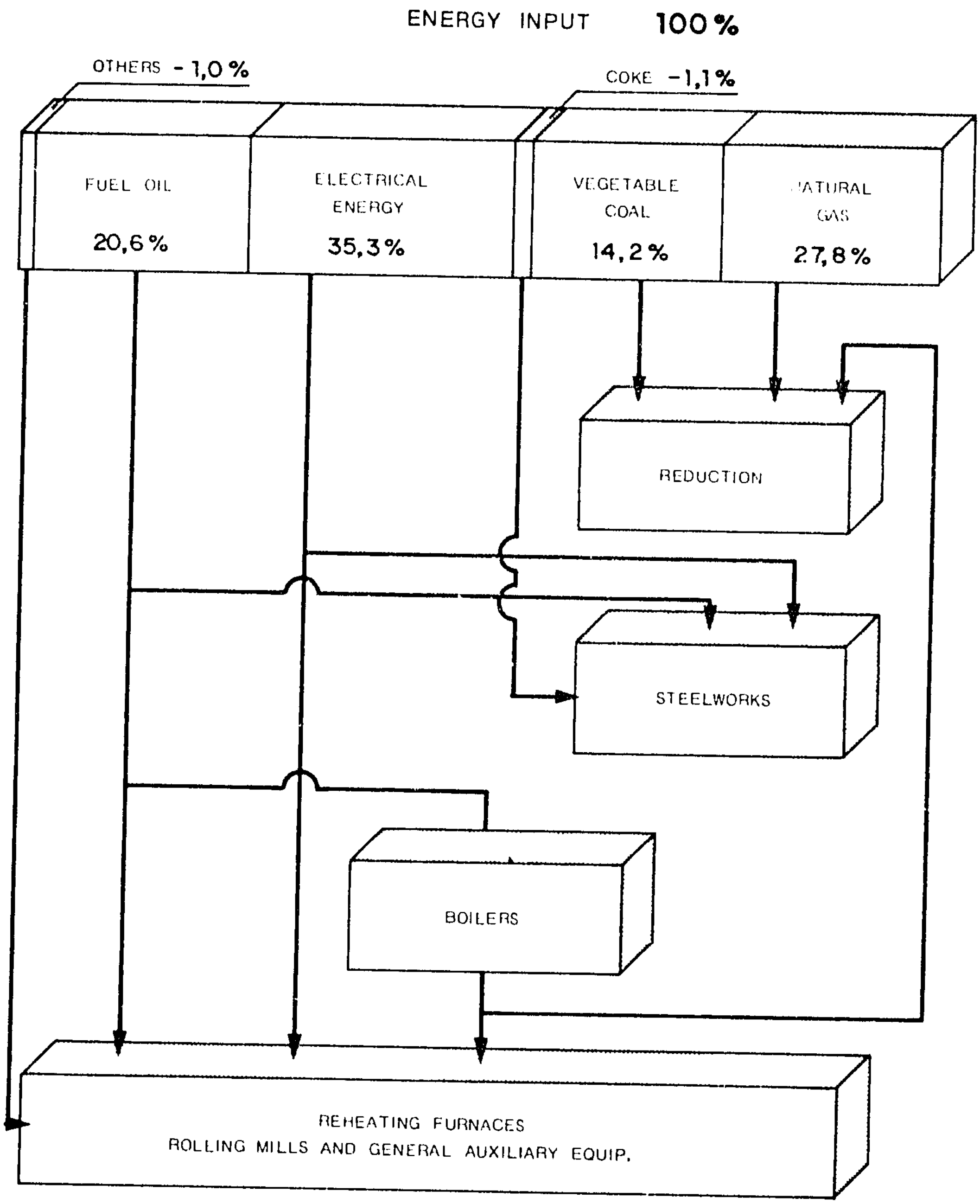

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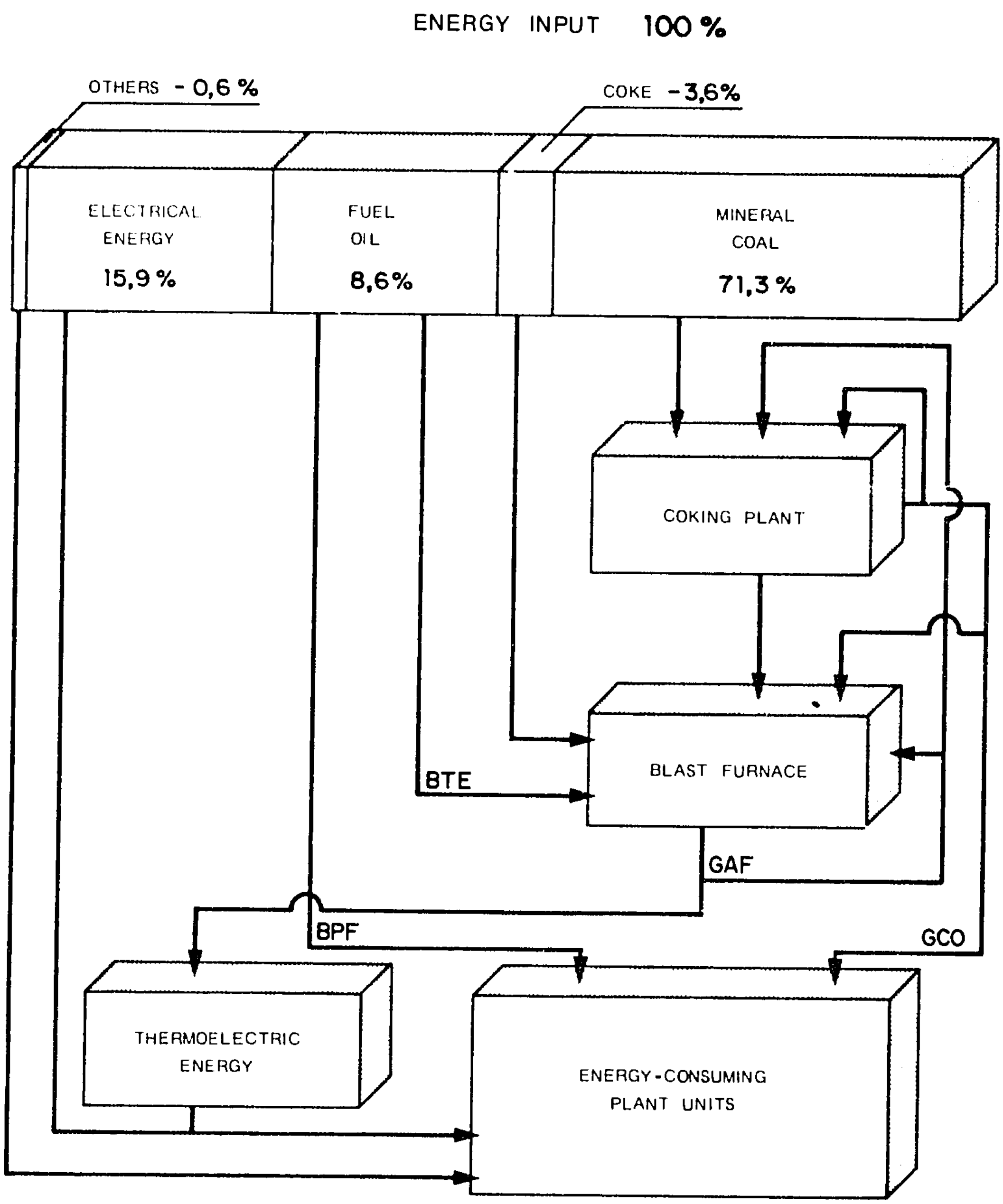

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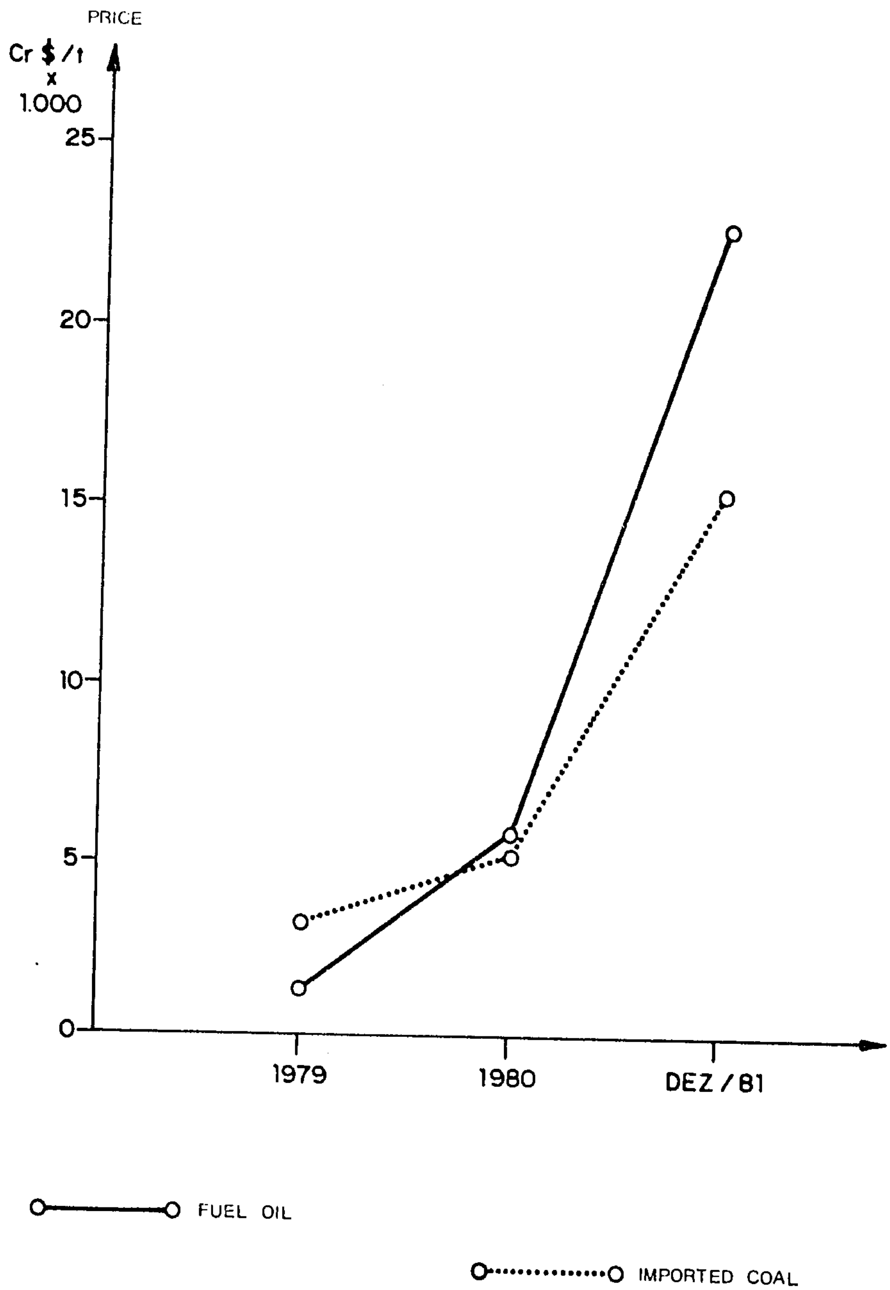

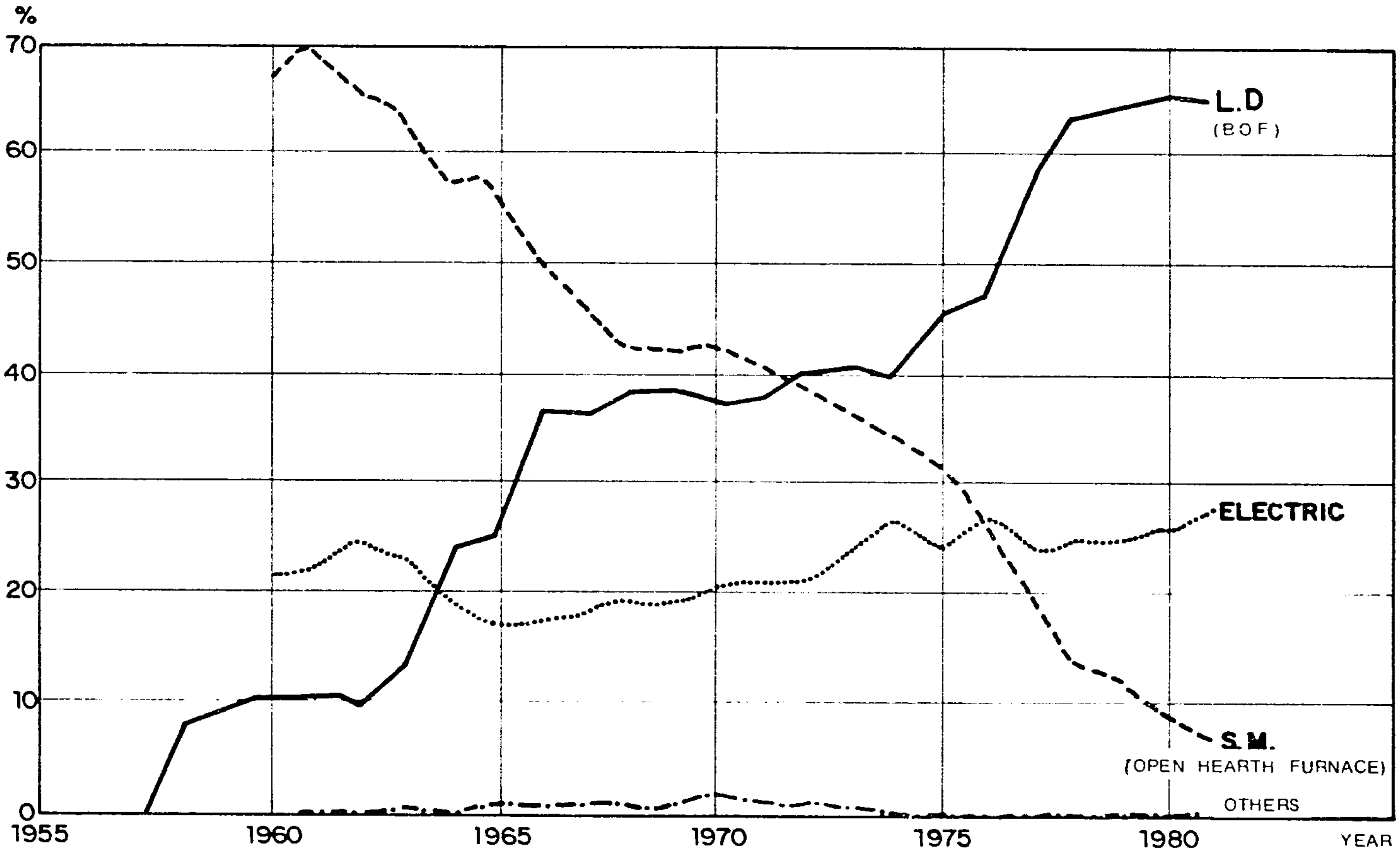

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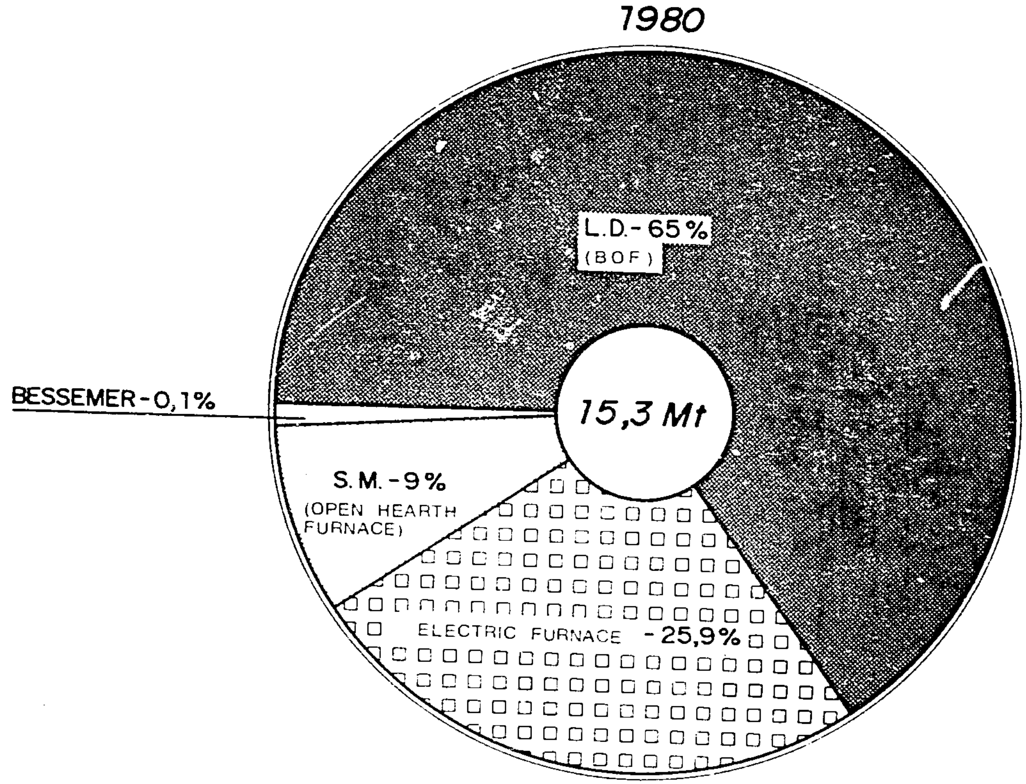

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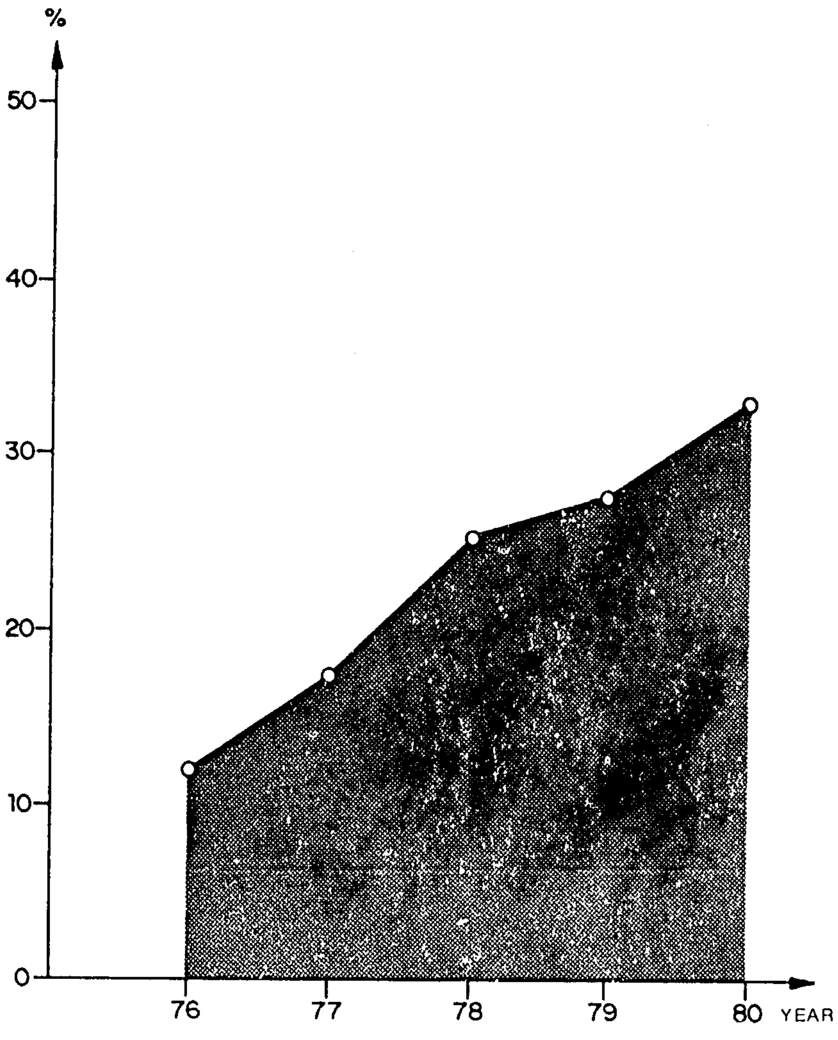

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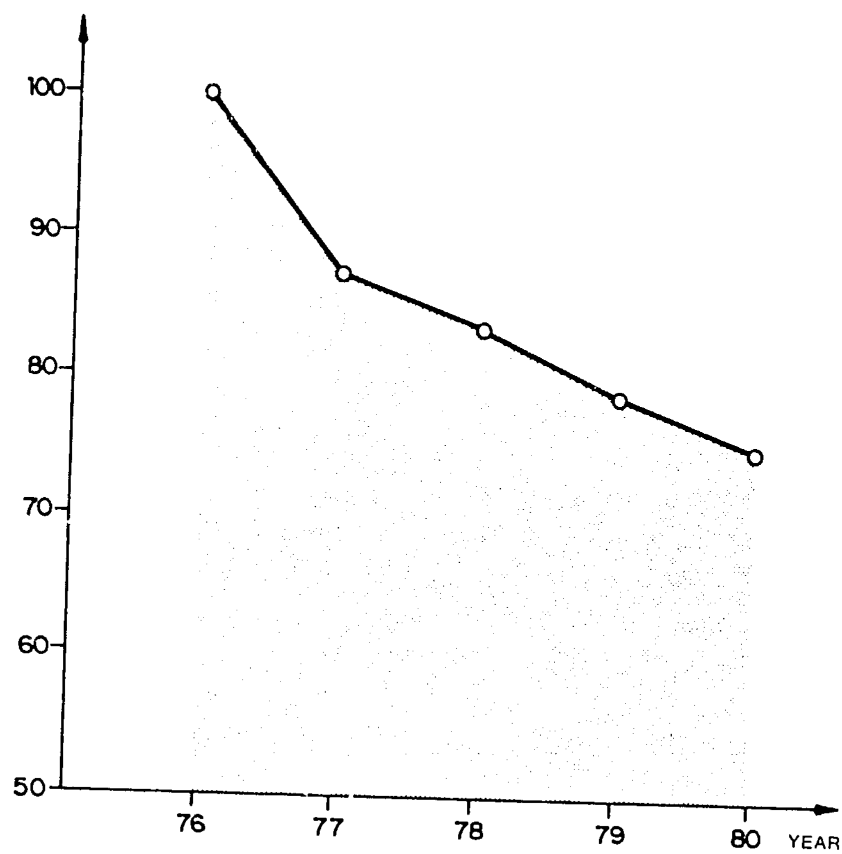

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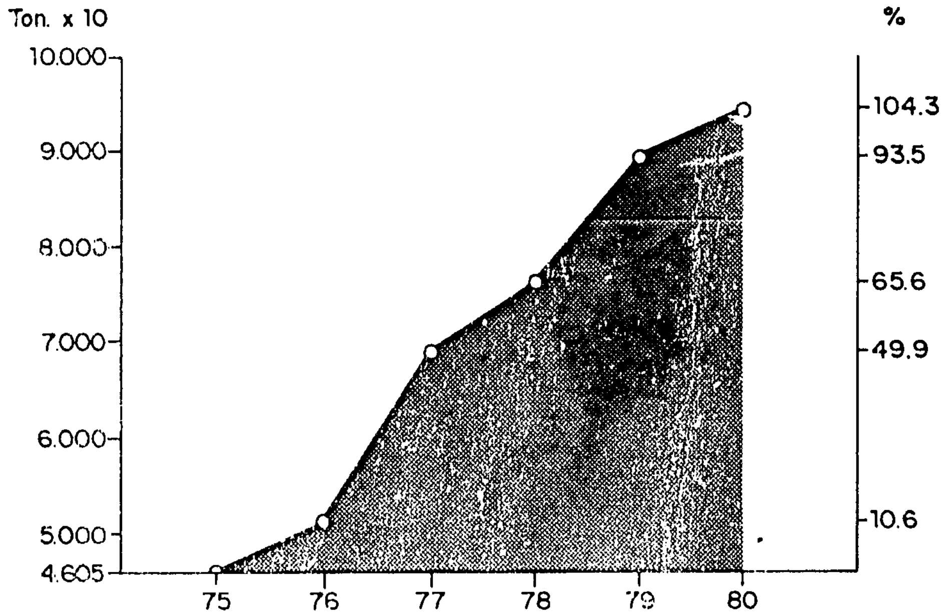

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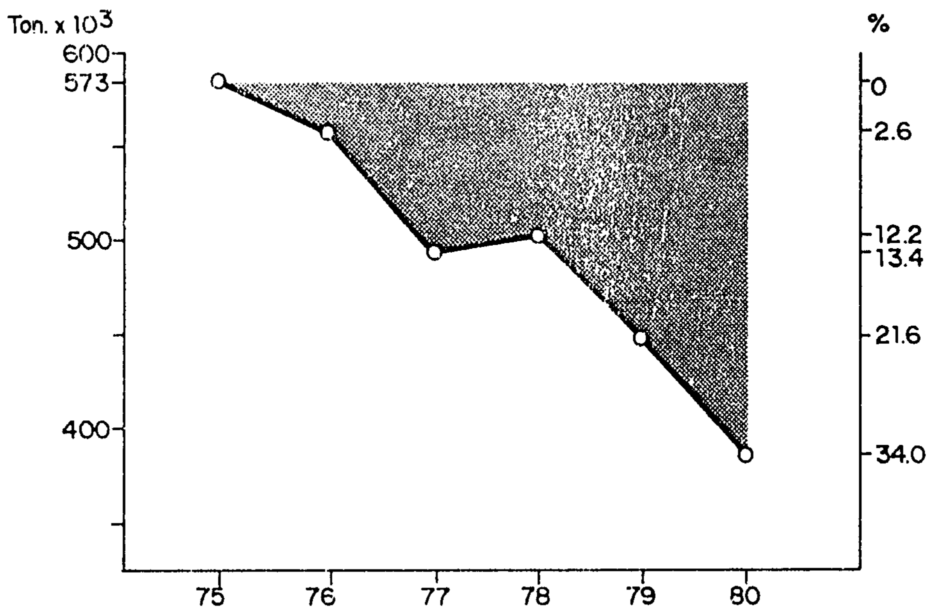

UNIT : KILO OF FUEL OIL/TONNE OF RAW STEEL

GROUP	CONSUMPTION 1978	TARGET JUN 81	ACTUAL JUN 81	REDUCTION %
B	118	72,2	66,5	43,6
C	93,1	68,0	67,9	27,1

Table I PRIVATE SECTOR PLANTS

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THE NEW ENERGY STRATEGY

1. PRELIMINARY CONSIDERATIONS

To give a firmer shape to the ideas put forward, this paper will now concentrate on the position at a single plant - the Solmer works. This works was chosen, first, because we were familiar with it, but also, above all, because of its simple structure and because it has the most efficient energy supply arrangements - with a high utilization rate for the blast-furnace gas (for heating the coke ovens and operating the blowers) and its own power station, which allows great flexibility when it comes to using the waste gases. However, all this could apply equally, or at least in part, to the Dunkirk and Sollac works as well.

Table 1 shows the production forecasts made in the plan for the French steel industry for 1986.

Note the following points:

(a) Coke production is running at full capacity, which implies a high heating rate and the use of low-volatile coal. Incidentally, Solmer's coking plant has one of the highest productivity figures in the world.

(b) The sinter plant output allows a sinter content of 80% in the charge for the blast furnace, which is considered the ideal amount.

(c) The annual pig-iron output of 3.7 million tonnes is well below the capacity of the two blast furnaces (4.2 million tonnes). Everything depends on how the market moves in the short term.

(d) The figure for slab production (by continuous casting exclusively) assumes self-sufficiency in scrap, i.e. that the works consumes all the scrap which it produces but purchases none from outside sources. There are technical and economic reasons for this choice. The hot-coal production is therefore directly proportional to the pig-iron output.

(e) The works covers all its heat requirements from the coal burnt in the coke ovens, apart from small purchases of coke breeze and of other sources of energy. Against this, the tar produced is sold to outsiders.

(f) The electricity bought in does not include the power generated on site using the waste gases, which covers approximately 40% of total consumption at this steelworks.

(g) Table 1 also shows the unit consumption per tonne of coil and per tonne of pig-iron. Where energy is concerned, all depends on the balance within the pig-iron plant (i.e. the sinter plant, coke oven battery and blast furnace), which is why it is important to express all the figures in relation to one tonne of pig iron. The energy balance of the blast furnace becomes a key factor and is therefore described in the next Section.

II. OPERATIONAL DATA FOR THE BLAST FURNACES

Together, the production figures for the coking plant - 1 480 000 tonnes of dry, screened coke suitable for the blast furnace - and the planned blast furnace output of 3.7 million tonnes suggest that the works has a supply of exactly 400 kilogrammes of coke for each tonne of pig iron poured. Even on the most optimistic hypothesis, this is far too little to produce one tonne of pig iron. Something else is needed - either coke bought from outside sources, or oil or coal injected via the tuyères. Since the work produces surplus rich gas, its basic plan is to inject the excess coke-oven gas through the tuyères of its twin blast furnaces. Where different energy-supply conditions prevail, however, the following alternative injection operations could be envisaged:

(i) either the residual gas, after hydrogen has been extracted from the coke-oven gas; or

(ii) coal; we have assumed that injection of a 25%:75% water/coal mixture would be more advantageous than pulverized coal injection bearing in mind the energy-supply conditions at this works. Naturally, that is assuming that the method is sufficiently developed, which remains to be demonstrated. None the less by and large the conclusions drawn in this study could be applied to pulverized coal injection too, if need be.

Table II sets out the main operational data for the blast furnaces, as calculated on a mathematical model of the IRSID blast furnace. Note that the calculations assume that the gas in the throat of the furnace remains at a constant 100°C in all cases.

It is clear that:

(i) the level of injection is relatively modest in all the three cases considered to avoid all combustion problems and to permit use of the model;

(ii) the key operational parameters (blast rate, gas flow rate and flame temperature) are relatively close in all three cases. It is therefore fair to imagine that it is possible to switch from one mode of operation to another with minimum difficulty (assuming a constant coke rate equivalent to 400 kg per tonne of pig iron). Mixed injection could even be contemplated, with some tuyères fed with gas and others with slurry;

(iii) nevertheless injection of slurry tends to increase the heat consumption slightly and to produce an appreciably richer gas (direct and indirect overcharging with oxygen).

III. REFERENCE POSITION: INJECTION OF COKE-OVEN GAS VIA THE TUYERES

As indicated in pages 877 to 890 of the November 1981 issue of the Revue de Métallurgie, the current trend in the energy balance of modern integrated steelworks is towards far lower heat requirements for operations downstream of the blast furnace.

Overproduction of coke-oven gas is the inevitable result of this change, in which everything plays a part, including:

(i) the general application of continuous casting;

(ii) the lowering of the heat requirements for the furnaces;

(iii) the charging of hot slabs;

plus

(iv) recovery of the converter gas.

This will be the situation at the Dunkirk works in 1986; it will be even more marked at the Solmer plant with:

(i) low downstream heat consumption;

(ii) the coke ovens heated by gas mixtures with a low NCV;

(iii) steam blowers.

Solmer overcame this problem and at the same time avoided the extremely wasteful solution of burning the coke-oven gas in the power station by injecting the gas into its two blast furnaces instead. We could then calculate the overall energy balance for a given period - whether year, month, day or hour. All the figures have been related to the production of one tonne of pig iron. Table III accordingly gives the consumption of the various types of gas (coke-oven gas, LD-converter gas, blast-furnace gas, and, in the case of the blast furnaces, oxygen) per tonne of pig iron for each of the main units in the works.

The following points should be noted:

(a) the Table does not indicate coal consumption in the coke ovens, coke breeze purchases, oxygen consumption in the converter, nor tar sales; these are all factors which will remain constant;

(b) the total consumption of residual gas is:

	2150 thermies per tonne of pig iron
of which	912 thermies (42.4%) is coke-oven gas
	170 thermies (7.9%) is LD-converter gas and
	1068 thermies (49.7%) is blast-furnace gas;

(c) the consumption figures for each unit are those postulated by the works for 1986. The figure of 300 thermies per tonne of slab in particular represents a moderately ambitious reduction; as charging of hot slabs becomes far more common, a much bigger reduction should be attained.

(d) the main consumers of the coke-oven gas are, in order of consumption:

blast furnaces:	448 thermies	(49%)
slabbing mills:	281 thermies	(32%)
coke ovens:	103 thermies	(11%)

Consumption by the blast preheaters is negligible, since they burn mainly LD-converter gas and sensible heat recovered from the flue gases.

This arrangement leaves 44 thermies which are not directly used, but are burnt in the power station or cope with any increase in demand.

(e) all the LD-converter gas is used to heat the blast preheaters;

(f) the blast-furnace gas is used in the most efficient way possible:

blast preheaters:	328 thermies	(31%)
coke ovens:	252 thermies	(24%)
blower:	202 thermies	(19%)

The power stations consume most of the rest.

To sum up, four conclusions can be drawn:

A. In 1986 - assuming self-sufficiency in scrap - Solmer will be running entirely on coal for the specified level of pig iron production; it will be buying electricity to top-up, but selling the tar which it produces.

B. This situation implies making extensive use of the coke-oven gas, practically half of which will be injected into the tuyères of the blast furrace. This rules out injection of any other sort. At present, Solmer could not opt for coal injection, however much it wanted to.

C. In these conditions the works supplies its power station with enough surplus gas for an output of approximately 110 kWh per tonne of pig iron - the equivalent of 48 MWh - saturating one of the two generators and far beyond the minimum emergency power level required.

D. Any improvement in the heat balance, whether achieved by reducing specific consumption or by more widespread charging of hot slabs, releases coke-oven gas which has to be burnt in the power station for want of a better solution.

Nor do improvements in the heating efficiency to reduce the NCV needed to heat the coke ovens bring any advantage apart from substituting coke-oven gas for blast-furnace gas in the power station.

In short:

In sharp contrast to the situation in Japan, the situation in France, at a works such as Solmer, blocks changes of any kind in energy supply conditions, since it precludes coal injection and gives steelmakers no incentive to take any other energy-saving measures.

IV. HYDROGEN EXTRACTION

As stated in the Revue de Métallurgie referred to above, extraction of hydrogen for use outside the steelworks gives greater room for manoeuvre in the energy balance of an integrated steelworks.

Without going into the details, suffice it to say that:

(i) recent studies based on solid industrial experience have shown that extraction of hydrogen from coke-oven gas by pressure-swing absorption (PSA) poses no particular problems provided certain precautions are taken at the gas compression stage.

(ii) There is no denying the general benefit of this operation from the energy point of view, as compared with the conventional production of hydrogen by steam reforming, since only electricity is consumed.

(iii) What is more, extraction at high pressure (i.e. 24 bars) also provides a means of recovering benzol with minimum difficulty.

For these reasons Solmer is now exploring the possibility of supplying a refinery in Fos with some 65 tonnes of hydrogen per day from its coke oven battery.

Table IV gives a survey of the consequent new energy balance, based on the following assumptions:

(i) Two-thirds of the coke-oven gas, i.e. 608 thermies per tonne of pig iron, is compressed at 24 bars (a process which consumes 29 kWh) and then treated in a PSA unit with an output of:

(a) 32 thermies benzol }
(b) 185 thermies hydrogen } per tonne of pig iron.
(c) 391 thermies residual gas }

The residual gas from the PSA unit is discharged for injection into one of the two blast furnaces and the remainder is passed on to the slabbing mill.

(ii) The coke-oven gas, LD-converter gas and blast-furnace are all put to the best possible use, in the manner already described.

However, steps must be taken to compensate for the energy deficit brought about by the decision not to inject gas into the second blast furnace. We have assumed that these took the form of injecting slurry into the second blast furnace and maintaining a coke rate of 400 kg per tonne of pig iron, in line with the figures set out in Table II.

Table IV shows that:

(a) Of the 391 thermies of residual gas:

(i) 229 thermies are injected into one of the blast furnaces; and
(ii) 162 thermies are used in the slabbing mill.

(b) Of the 304 thermies of coke-oven gas not treated by PSA:

(i) 119 thermies are used in the strip mill;
(ii) 103 thermies in the coke-oven; and
(iii) 29 thermies in the sinter plant.

That leaves 52 thermies for the power station.

(c) Otherwise, there is little or no change for the LD-converter gas and blast-furnace gas compared with the reference position.

This therefore points to the conclusion that:

A. Extraction of hydrogen from two-thirds of the coke-oven gas would not only bring the direct benefit of hydrogen production but also would allow of coal injection into one of the blast furnaces. Coal injection for half of the pig iron output should be interpreted as meaning that mixtures of residual gas and slurry could also be injected as an alternative. This would be an interesting field for experiments with different settings (and in particular a means of reducing the discharges of rich gas to the power station), but we are not going any further along this path for the time being.

B. To a certain extent the operation suggested entails withdrawing the energy - previously injected (in the form of coke-oven gas) into the tuyères of one of the blast furnaces - from the energy cycle in the steelworks and replacing it by a comparable supply of energy derived from coal. It entails no further changes in the operation of the other plant. Consequently, there is no technical risk. But nor is there any prospect of technological innovation, apart from coal injection, which would be a start at least. This solution leaves no openings for other potential energy-saving installations.

C. To return to the problem of hydrogen as such, analysis of the energy balances compared in Tables III and IV shows that extraction of hydrogen results in:

(i) Extra consumption of 29 kWh per tonne of pig iron within the PSA unit, a 12 m^3 stp increase in oxygen consumption per tone of pig iron, with, on the plus side, a 9.5 kWh increase in electricity output from the power station; and

(ii) consumption of 33.2 kg of coal per tonne of pig iron poured and the production of 185 thermies of hydrogen and of 32 thermies of benzol.

Table V sums up the net result.

Production of one tonne of hydrogen results in:

(i) the consumption of 5 160 kg of coal and of 4 340 kWh of electricity;

(ii) the production of 520 kg of benzol.

The operation therefore appears to be an attractive proposition from the point of view of:

(a) absolute energy supply; and
(b) containing energy consumption.

V. METHANOL PRODUCTION AND USE OF ELECTRICITY

So far we have seen that simple extraction of hydrogen from two-thirds of the coke-oven gas produced entails significant changes in the general conditions at the steelworks. However, the introduction of coal injection in one of the blast furnaces minimized the impact. In practice, other combinations are feasible, but we preferred to look at the question in a wider context.

Extraction of hydrogen has certain attractions in terms of the national interest. However, these are less apparent to the steelmakers or even to the oil company at the Fos site, where there is no obvious immediate need for a new hydrogen production unit, whether to cover new demand or to replace obsolete units. To make matters worse, the refineries themselves, like the steelworks, produce a variety of waste products and use them profitably on site.

This Section therefore places the problem in the wider context of methanol production. J. Cordier has proposed such a solution for the Usinor works. This Section simply transfers his scenario to Solmer.

Production of methanol from the waste gases from the steelworks is tempting since:

(i) substantial expansion of methanol production is expected, with heavy investment in this field in France;

(ii) the steelworks has extensive supplies of the two raw materials required - H_2 AND CO;

(iii) as a liquid, methanol overcomes the problem of confinement to the steelworks, i.e. to the works site or to the larger industrial estate as at Fos.

This Section therefore sets out from the premiss that:

(i) the works extract hydrogen (and of course benzol) from as much of its coke-oven gas as possible;

(ii) exactly the volume of LD-converter gas needed to supply enough CO to give a stoichiometric ratio of 1 CO: 2 H_2 is recovered;

(iii) the works suffers from a deficit of gas, or at least of rich gas, compared with the reference position; consequently, maximum use must be made of blast-furnace gas as basic fuel;

(iv) against this background, there is a chance of a deficit in blast-furnace gas, which would open up new prospects for technical progress (including charging slabs while thet are still hot in all cases, dry quenching and so on).

Table VI gives a specific example.

The new system entails bringing into service a dry quenching unit supplying steam at high pressure (100 bars) direct to the blowers of the blast furnaces. A new materials balance can be calculated, to allow for the introduction of a new source of approximately 150 thermies per tonne of pig iron and for the minimization of power station activity.

It can be seen that:

(a) some 88% of the coke-oven gas is treated in the PSA unit to release 243 thermies of hydrogen, corresponding to an output of 67.5 kg of methanol (and 43 thermies of benzol) per tonne of pig iron produced;

(b) following treatment in the PSA unit, the waste gases are essentially injected into the two blast furnaces, which require no further fuel. The remaining waste gas is channelled to the slabbing mills.

(c) The 12% or so of the coke-oven gas not treated in the PSA unit is passed on to:

(i) the coke-oven heating system;

(ii) the sinter plant; and

(iii) the slabbing mills.

Note the proportion of the coke-oven gas used to heat the coke ovens. We assumed that the progress in automatic heating of the ovens would make it possible to reduce the NCV of the gas mixtures used for this purpose at the Solmer works to 800 kcal/m^3 stp.

(d) Extensive use is made of the blast-furnace gas in the blast preheaters and in the slabbing mills. This would necessitate technological changes in both (particularly in the slabbing mills), though this is another problem. It would also entail massive use of oxygen to keep the flame temperature at the reference level.

(e) The total volume of oxygen therefore becomes an important factor with:

(i) 48 m^3 stp/tonne of pig iron required for the blast preheaters;

(ii) 19 m^3 stp/tonne of pig iron for the blast furnace;

(iii) 47 m^3 stp/tonne of pig iron for the slabbing mills.

This far surpasses the current production capacity of the works.

A new oxygen unit would therefore have to be constructed, though the oxygen could be of appreciably lower purity than that used for conversion.

(f) Finally, this system leaves little to supply the power station and for electricity generation there. It would therefore entail a substantial increase in electricity consumption to meet the standard requirements of the works.

Using the same presentation, Table VII shows the energy requirements for methanol production.

For want of further data, we have assumed that the hydrogen and LD-converter gas are supplied to a methanol production unit on the work site, with:

(i) the hydrogen in the form of pure hydrogen at 24 bars; and

(ii) the CO in the form of untreated LD-converter gas at low-pressure.

That said, the figures show that:

(i) it is possible to produce 67.5 kg of methanol plus 4.3 kg of benzol in return for consumption of 102 m^3 stp of oxygen and of 134 kWh per tonne of pig iron; or, put differently,

(ii) production of one tonne of methanol entails consumption of 3 040 kWh, though, on the plus side, 64 kg of benzol is produced at the same time.

To sum up, the following conclusions can be drawn:

A. Methanol production fits in perfectly with the activities of an integrated steelworks for which the operation is an attractive means of exploiting the hydrogen in the coke-oven gas and the CO in the LD-converter gas.

B. Opening up the works in this way allows a bold policy of using the blast-furnace gas, doped with oxygen.

C. Utilization of blast-furnace gas in this way creates a need to tap new potential sources of energy, for example to dry-quench the coke.

D. This results in increased electricity consumption, linked with:

(i) the power needed to extract the hydrogen;

(ii) oxygen production;

(iii) the lower level of activity in the power station.

All this is a good example of greater penetration by electricity with a view to producing hydrocarbons.

Finally, note that this system employs exclusively conventional methods, all based on highly-reliable technology.

VI. METHANOL PRODUCTION AND USE OF COAL

However tempting the system described above may be on the purely intellectual level, it is not without its shortcomings:

(i) It makes extensive use of electricity, which is still an expensive source of energy for much of the year;

(ii) It requires heavy investment in dry quenching, in the tonnage oxygen plant, in technological adjustments to the blast preheaters and, above all, to the slabbing mills.

Assuming that coal remains the cheapest source of energy, at least for the next few years, an alternative system could be contemplated, once again with coal injection via the tuyères of the blast furnace. We will therefore now look at the same basic system for the coke-oven gas, with the exception that no residual gases are injected through the tuyères. This provides the works with a large surplus of rich gas to burn in the blast preheaters and slabbing mills.

Table VII shows that:

(a) The volume of coke-oven gas treated remains the same, though in this case it would be possible to increase the output of treated coke-oven gas (whereas in the previous case a flow of rich gas to the slabbing mills had to be kept up to maintain the heat balance for the rich gas/producer gas/oxygen).

(b) Dry quenching has also been retained. In fact this is purely for comparison with the previous example, since with the surplus gas available the dry-quenching unit is not necessarily warranted in this case.

(c) There are no particular technological difficulties. There is a substantial surplus of rich gas for burning in the power station - an acceptable solution in winter. There is also a substantial surplus of blast-furnace gas, which likewise poses no problem.

Now we can proceed to establish a summary identical to the other one for methanol production.

Based on the same hypotheses as the previous Section (see Table VIII):

Consumption of 66.4 kg of coal combined with 17 m^3 stp of oxygen per tonne of pig iron yields 67.5 kg of methanol, 4.3 kg of benzol plus an extra 33.2 kWh of electricity.

Consequently, 984 kg of coal is needed to obtain one tonne of methanol with this system, though 64 kg of benzol and 316 kWh of electricity is also produced in the process.

This is therefore another attrative system for deriving methanol (and benzol), this time with the aid of coal.

Perhaps the chief attraction of the system is that it does not conflict with the previous one. We know blast-furnace operators well enough to be sure that they would be prepared to contemplate seasonal operation, i.e.:

(i) during the "summer" season, of seven or eight months, gas would be injected via the tuyères; and

(ii) during the "winter" season, covering the rest of the year, coal would be injected.

We are convinced that they would be prepared to accept this adjustment, provided they received assurances that there would be no change in the:

(i) coke rate, which is an essential precondition for maintaining a stable gas flow; or

(ii) production rate.

The system has two further consequences.

1. Injection of slurry is far preferable in this system since:

(a) It is adopted only in winter, when there is no problem exploiting the gas - on the contrary.

(b) The investment costs are far lower.

2. Dry quenching is also put to good use, releasing blast-furnace gas for heating purposes in the summer and for electricity generation in the winter.

Finally, this system does not preclude adopting a hybrid solution all year round, with simultaneous injection of residual gas and coal into the two blast furnaces, and with facilities for modulating the input:

(a) either on a seasonal basis, with coal predominating in winter and residual gas in summer; or

(b) instantaneously (for the blast furnaces) to adjust to the energy supply conditions of the moment.

This would be a remarkable new role for the blast furnace, which would regulate the energy supply in the steelworks. Admittedly, the operators remain to be convinced.

SUMMARY AND CONCLUSIONS

Once the investment and technical progress programme provided for by the new plan for the steel industry has been fully implemented, integrated steelworks in France will find their efforts to save energy blocked, since they are all directed towards the generation of electricity.

To take one example, by 1986 a works such as Solmer will be producing a substantial surplus of rich gas (i.e. coke-oven gas or LD-converter gas), compared with the volume traditionally required by its blast preheaters, slabbing mills, etc. One solution is to inject the surplus coke-oven gas (almost half the total production) via the tuyères of the blast furnace. This solution has two immediate consequences:

1. It rules out coal injection and the considerable benefits which it brings.

2. It provides no incentive for any further effort to save energy, since any savings made would automatically add to the surplus of electricity.

Opening up steelworks to the outside world - in other words, allowing them to supply some of the energy from their rich waste gas to other industries - allows considerable room for manoeuvre. These energy sales permit:

(i) the introduction of coal injection for all or part of the pig-iron production; and

(ii) substantial purchases from EDF, both directly (i.e. for compression and for oxygen production) and indirectly (i.e. since the increased use of blast-furnace gas as a fuel leads to a corresponding reduction in the volume of blast-furnace gas burnt in the power station).

Two methods of opening up the works were considered:

1. Extraction of hydrogen from the coke-oven gas to supply a refinery on the perimeter of the Fos oil complex. This operation allows coal injection through the tuyères, but is not enough to cause any profound changes in the energy supply conditions at the works. It is a simple operation drawing on proven methods and a suitable first step in a more ambitious development plan.

5. Production of methanol from the hydrogen extracted from the coke-oven gas combined with the CO from the LD-converter gas. This more far-reaching intervention in the energy balance of the works allows a more ambitious policy: above all, the intensive use of blast-furnace gas as the basic fuel for the various mills and furnaces creates a new situation, with the steelworks suffering from a deficit of producer gas. This opens up an opportunity to exploit new potential for energy-saving, for example by dry-quenching of the coke.

Outside topping-up supplies would also have to be called on:

(i) electricity, in view of the intensive use of oxygen and of the drastically-reduced potential for on-site generation;

(ii) coal for injection via the tuyères of the blast furnances.

Far from running against one another, we feel that these two solutions could complement each other harmoniously:

(a) Electricity could be used during the seven or eight "hot" months, when the kWh price is low enough to make electricity competitive;

(b) Coal could be injected during the four or five "cold" months.

Table X sums up the main results. It shows how the primary energy (electricity and coal) is converted into more complex forms (H_2 for the refinery or H_2 and CO for methanol production) as it passes through a conventional steelworks employing each of the methods examined.

Our detailed analysis of the different systems points to two conclusions:

1. All the cases examined use only highly-reliable proven methods; the only problem is to fit the pieces of the jigsaw together to give a rational pattern;

2. The primary energy is converted into more complex forms exceptionally efficiently since, with the exception of the electricity used for mechanical purposes (such as the compression stage of hydrogen extraction or for hydrogen production) no heat is lost other than in the inevitable ways.

The comments made on the Solmer works hold true for the Dunkirk and Sollac plants as well. France's three largest steelworks are ideally placed for further energy improvements, all in line with the broad thinking underlying the national energy policy.

TABLE

MATERIALS BALANCE

SOLMER 1986

OUTPUT PER UNIT	'000 t	per tonne of coil (kg)	per tonne of pig iron (kg)
SINTER	5300	1480	1440
COKE			
TOTAL	1680		
BF	1480	417	400
PIG IRON	3700	1042	1000
SLABS	3625	1022	980
HOT COILS	3550	1000	959

ENERGY PURCHASES

	'000 t	'000 toe
COAL (dry)	2160	1663
COKE BREEZE	40	28
SCRAP	–	–
OTHER FUELS		6
ELECTRICITY	610 GWh	

ENERGY SALES

	'000 t	
TAR	62,6 KT	54,2

TABLE II

OPERATIONAL DATA FOR THE BLAST FURNACES

METHOD OF INJECTION	COKE-OVEN GAS	WASTE GAS	WATER (25%) COAL (75%) MIXTURE (SLURRY)
BLAST TEMPERATURE (°C)	1300	1300	1300
MOISTURE CONTENT OF THE BLAST (g/m^3 stp)	10	10	10
COKE RATE (kg/tonne of pig iron)	400	400	400
INJECTION (kg/t)	41.6	54.5	66.4*
(thermies per tonne of pig iron)	448	458	485
NATURAL BLAST (m^3 stp per tonne of pig iron)	939	930	916
O_2 m^3 stp/tonne of pig iron	11.9	19.3	29
FLAME TEMPERATURE (°C)	2245	2250	2269
VOLUME OF GAS (dry) m^3stp/tonne of pig iron	1420	1423	1430
LATENT HEAT (thermies/ tonne of pig iron)	1068	1078	1090
NCV kcal/m^3stp	754	758	765

*DRY COAL

Table III

CASE I

INJECTION OF COKE-OVEN GAS INTO BOTH BLAST FURNACES

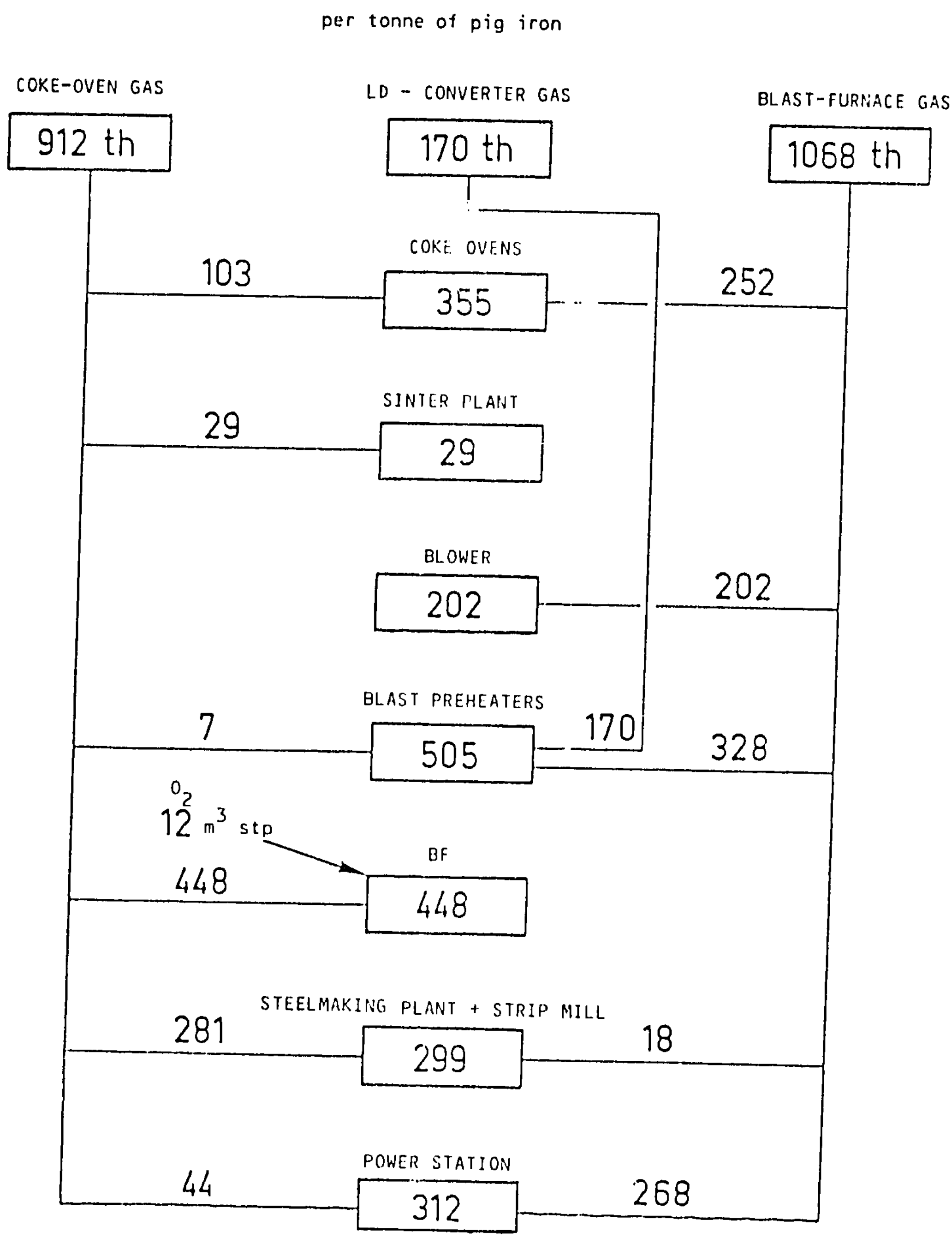


Table IV

CASE II

EXTRACTION OF H_2

INJECTION OF WASTE GAS INTO ONE BLAST FURNACE

INJECTION OF SLURRY INTO THE OTHER BLAST FURNACE

per tonne of pig iron

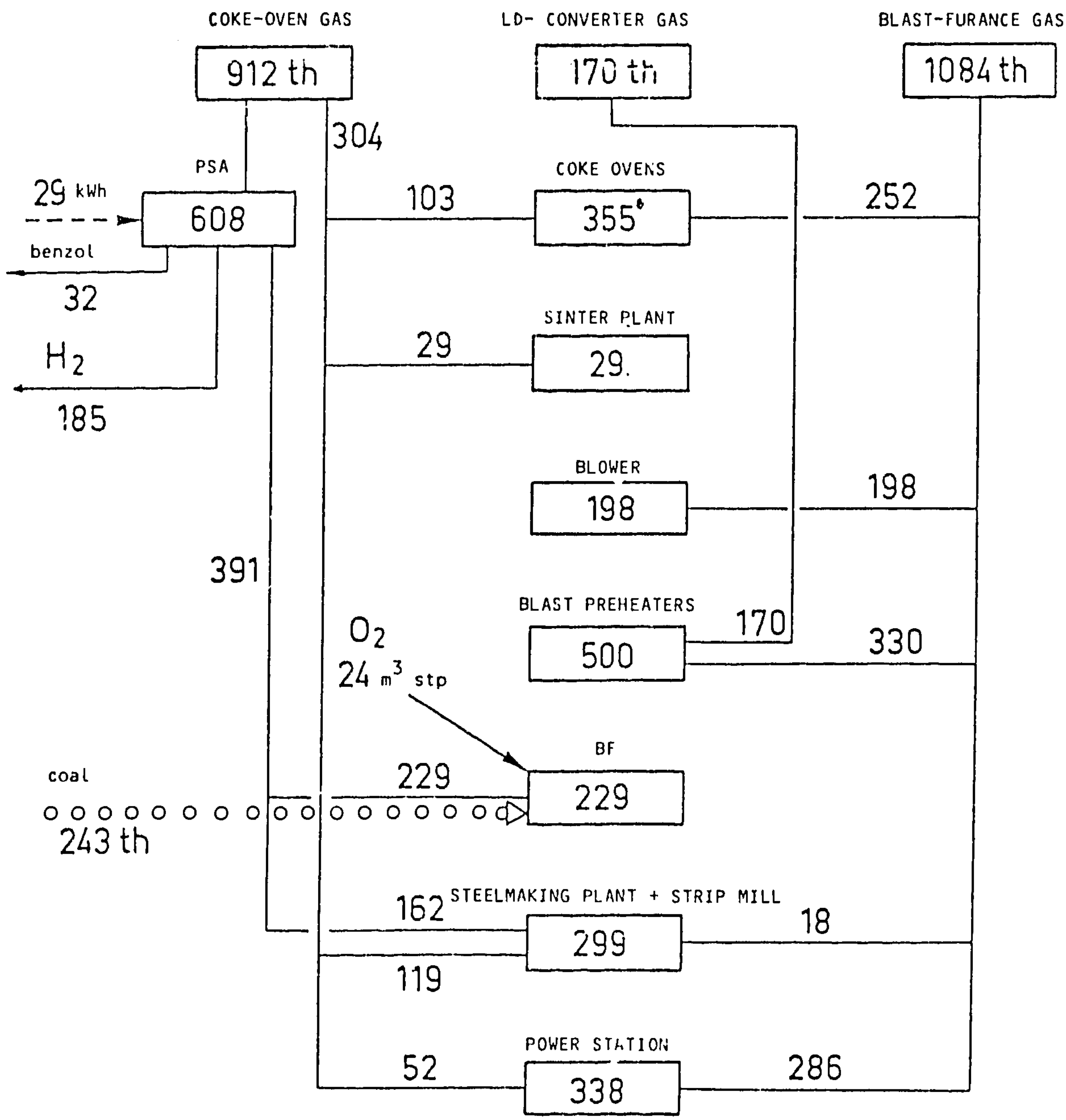


Table V

HYDROGEN EXTRACTION

per tonne of pig iron

12 m^3 stp O_2 +19.5 kWh +33.2 kg coal	=	72 m^3 stp/H_2 + 3.2 kg benzol

per tonne of hydrogen

1 tonne H_2	=	4.340 kWh * +5160 kg coal -520 kg benzol

* 1 m^3 stp O_2 = 0.7 kWh

TABLE VI
CASE III

METHANOL PRODUCTION
INJECTION OF WASTE GAS INTO BOTH BLAST FURNACES
per tonne of pig iron

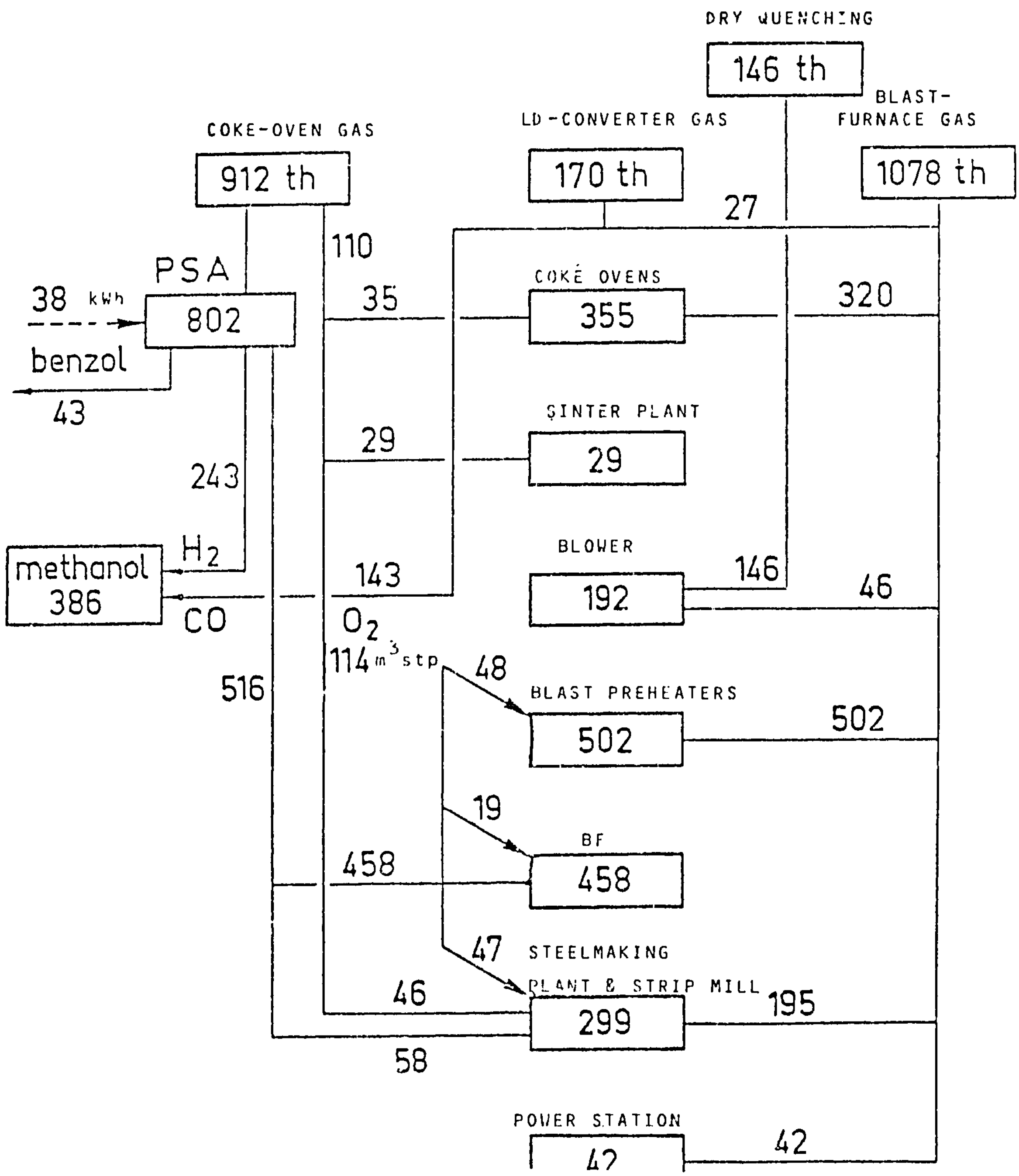


TABLE VII

PRODUCTION OF METHANOL
(IN ADDITION TO THE ENERGY FOR STEELMAKING)
WITH THE AID OF ELECTRICITY

per tonne of pig iron

102 m^3stp O_2 + 134 kWh	=	67.5 kg methanol + 4.3 kg benzol

per tonne of methanol

3040 kWh	=	1000 kg mèthanol + 64 kg benzol

TABLE VIII

CASE IV

METHANOL PRODUCTION

INJECTION OF SLURRY INTO BOTH BLAST FURNACES

per tonne of pig iron

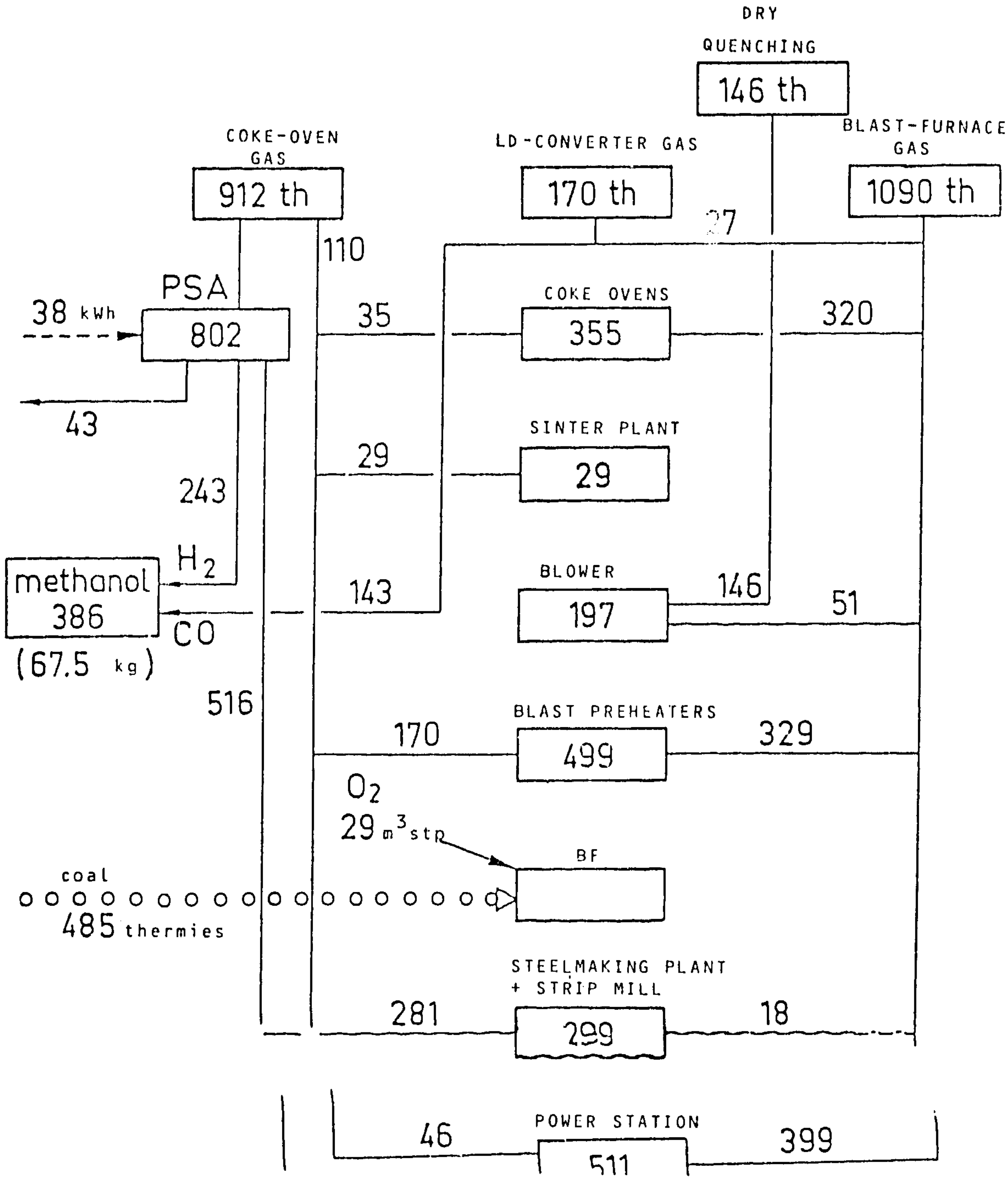


Table. IX

PRODUCTION OF METHANOL

(IN ADDITION TO THE ENERGY FOR STEELMAKING)

WITH THE AID OF COAL

per tonne of pig iron

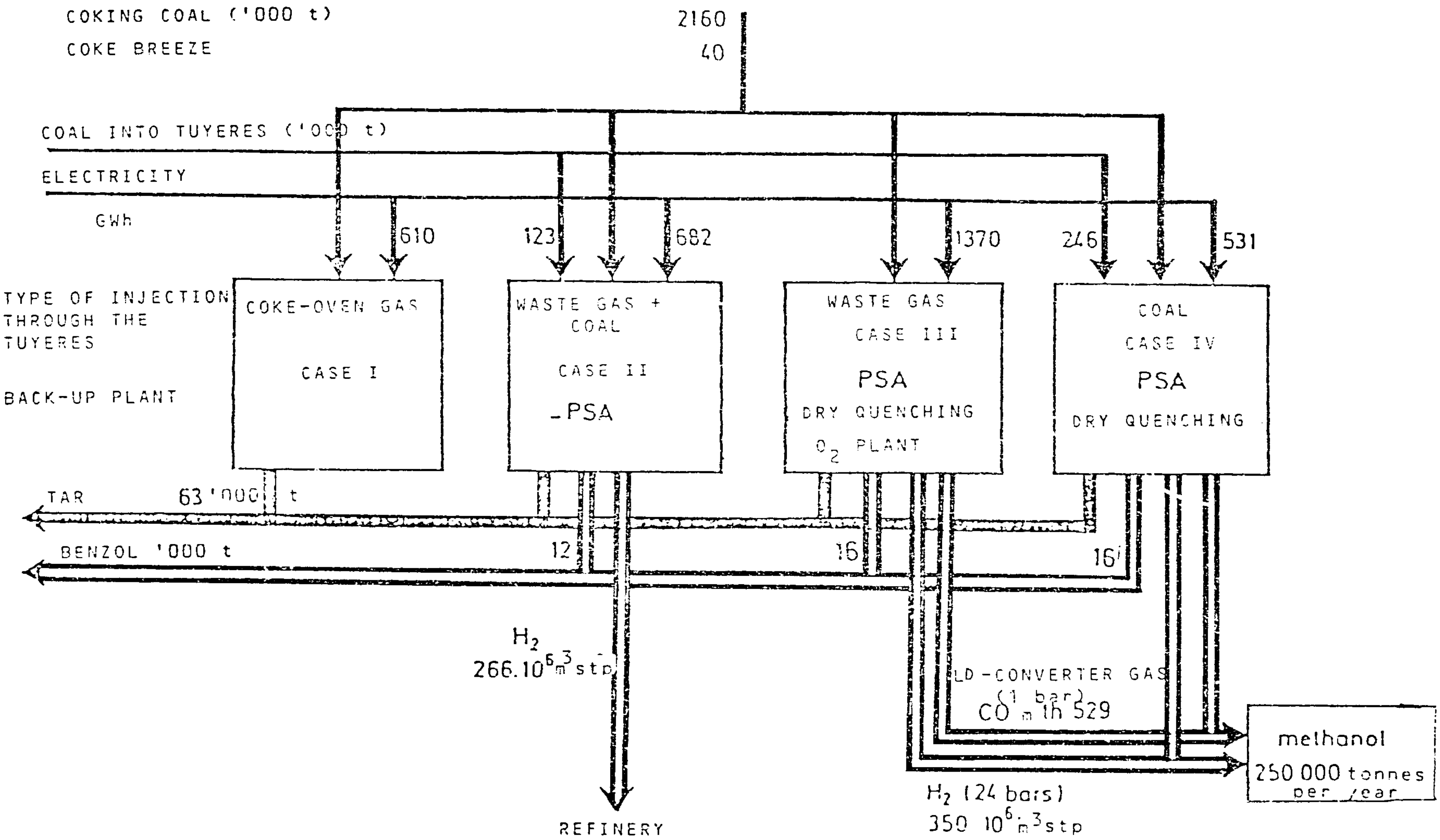
17 m^3stp O_2 + 66.4 kg coal	=	67.5 kg methanol + 4.3 kg benzol 33.2 kWh

per tonne of methanol

984 kg coal	=	1000 kg methanol + 64 kg benzol + 316 kWh

Table XI

CASE-BY-CASE COMPARISON OF THE ANNUAL ENERGY BALANCE



Rational Use of Energy in the Iron and Steel Industry
"Experience with Blast Furnaces in Mexico"

Eli Campos Sandoval
Deputy Director
Altos Hornos S.A.
Mexico

Altos Hornos de México, S.A. (Mexican Blast Furnaces, Inc. - AHMSA) is an integrated iron and steel industry, which along with the Fundidora de Hierro y Acero de Monterrey and SICARTSA Companies, comprises the SIDERMEX group of paragrovernmental companies.

The firm was founded in 1941, with the government as its major stockholder alongside a minority of private capital; and the decision was made to establish it in the city of Monclova in the border state of Coahuila, approximately 1,000 kms north of Mexico City, the capital of the Republic. This location was decided upon because. although the city was relatively small, it had the greatest infrastructure that would allow access to coal deposits, 100 kms. north of town, and to iron ore, 340 kms. northeast, in the neighbouring state of Chihauhua as well as to the water supply from the Monclova River, so necessary for iron- and steel-making processes. Therefore, in 1942 construction was begun on the largest iron and steel complex in Mexico, and the second-largest in all of Latin America, with an original capacity of 100,000 tons per year of steel, providing work for 1,364 persons including workers, technicians and administrators.

At present, AHMSA has an installed capacity of three million tons per year of steel in ingots in its Monclova plants; and equipment is under construction that will increase this capacity to 4.2 million tons kper year in the medium term. The plants in Monclova provide employment for 20,000 workers as well as over 30,000 in the 38 integrated or associated companies included in the AHMSA group in the north and center of the country. This has made the company the most important factor in the development of the region of Monclova, the population of which already exceeds 220,000 inhabitants; and it is one of the cornerstones of the country's industrial and economic development.

The broad variety of its products may be summarized as follows:

- Hot-rolled sheet steels. For the shipping industry; manufacture of piping, storage tank lids and the manufacture of structures for the towers of electrical transmission lines.

- Cold-rolled, black sheet iron, mainly for the automotive and appliance industries.

- Sheet metal, for the manufacture of cans for the food industry.

- Rolled steel shapes, light and structural, round, hexagonal, sill, corrugated bar, wire rod, angle iron, channel iron and standard IPR-type beams for the metalworking and construction industries.

Its most important production departments are the following:

- 2 sintering plants;
- 1 pellet-making plant;
- 2 coking plants;
- 5 blast furnaces;
- 1 blast furnace steel mill;
- 2 B.O.F. steel mills;
- 2 continuous-batch machines;
- 1 sheet-steel hot-lamination department;
- 1 hot-lamination department for light and structural rolled shapes;
- 2 cold-lamination departments;
- 6 power plants;
- 3 oxygen plants;
- and production-support departments.

The processes employed generate substantial volumes of blast furnace gas and coke gas which become an internal energy supply for part of this company's requirements.

ENERGY USE POLICIES

Optimal use of all resources has been a constant concern for AHMSA since it began operating. In line with this policy, and with an eye to using the secondary energy sources that an integrated iron and steel mill produces, all the equipment that was originally designed to consume solid and/or liquid fuels has been modified.

For example, in its steam-generation plants, which initially burned coal and fuel oil, combustion systems have been installed that use coke gas and blast furnace gas as their main fuel and natural gas and/or fuel oil as back-up fuel. Likewise, its furnaces and reheating sows, burning diesel or fuel oil, have been modified to use coke gas as their principal heat sourace with natural gas as back-up.

Another very important aspect is the recycling of the energy given off by its electric generators which apply "combined-cycle" heat-recovery systems to permit the most efficient operation of these systems. Some of these applications have been in operation since 1946 when the recycling of internally-produced gases was begun. Since then, AHMSA has faithfully followed its policy of optimization of the consumption of its own energy sources; all its expansion projects have embodied this same philosophy.

As expansion plans increased the blast furnace facilities, the need for a fuel dispatch center was soon felt. This center would ration fuels on the basis of fluctuating availability and demand. In order to make maximum use of the coke gas and blast furnace gas generated in the plant, this fuel dispatch center began to operate in 1967. It centralized the measurement of the principal variables to provide a basis for optimal distribution. Thus, through the direct observation of these variables, gas losses to the atmosphere were reduced to a minimum.

Under the same guiding principles, a "Load Dispatch Center" began to function in 1972, permitting substantial savings through maximal use of the palnt's installed capaicty for electric power generation.

Other equally important energy savings, related directly to the production processes, include AHMSA's efforts to choose the most efficient equipment and processes, such as the following, which began operating in 1971:

- A blast furnace with a 1,600-ton-per-day capacity that operates with a TOP pressure of up to 1.2 Kg/cm^2 and air blown in at 1,100^oC,

- A steel mill based on three oxygen converters (BOF) with a capacity of 75 tons/batch each.

In 1976 Plant No. 2 went onstream. It is practically an integrated plant, operating in coordination with Plant No. 1, with the following facilities:

- A coking plant with a capacity of 2,300 tons/day of metallurgical coke.

- A blast furnace with a capacity of 4,800 tons of pig iron/day which operates with a TOP pressure of 1.5 Kg/cm^2 and air blown in at 1,200^oC, with a (Paul Worth) uniform load distribution system.

- A steel mill with an oxygen converter with a capacity of 125 tons/batch.

- A two-line continuous-batch machine for slabs up to 200 x 1570 mm.

- A power plant with a 170 ton-per-hour boiler, a turboblower with an air output of 4,500m^3/min., a 14.8-MW turbogenerator run on gas with a 50 ton-per-hour recovery boiler.

Currently, an iron ore concentrating plant with a capacity of 1,500,000 tons per year is being tested, as well as an iron pipeline 200 and 250 mm x 381.5 kms long, with the capacity to transport 4,500,000 tons of fine iron ore per year.

In the third quarter of this year, the following equipment will enter into operation:

- A pelletization plant with a capacity of 3,000,000 tons per year;
- A second oxygen converter with a capacity of 125 tons/batch;
- A second two-line continuous-batch machine for slabs of 200 x 1570 mn.

By mid-1984 another iron ore concentrating plant will begin its operations with a 3,000,000 ton-per-year capacity. Subsequently, 2 pig iron desulphurizing plants will be installed and equipment will be installed and modified in Plant No. 1 to improve the load distribution systems and work with a higher temperature of blown-in air, as well as to increase the petroleum injection rate in order to reduce the coke rate.

With these modifications, the steel production that was 100% open-hearth up to 1971 became only 35% open-hearth and 65% BOF in 1983 and will be 30% open-hearth and 70% basic oxygen furnaces by 1986.

THE PRESENT ENERGY CONSUMPTION SITUATION

Apendices II and IIA show the fuel distribution balances prepared on the basis of a 1983 production rate projected at 2.75 million tons of steel/year.

Heat is generated by employing the following fuels in the proportions shown:

Fuels generated in-plant:		
	Furnace gas	21.1%
	Coke gas	16.8%
Fuels pruchased outside:		
	Natural gas	58.6%
	Fuel oil	3.1%
	Diesel	0.4%

These fuels are distributed among 19 production departments which include over 450 heat-energy-consuming units. The table in Appendix I summarizes the different distribution alternatives.

Under these conditions the estimated cost of fuels purchased for the present year will be in the order of 4.289 billion pesos on the basis of prices supplied by PEMEX for this period.

It should be pointed out that if in-plant fuels were not recycled, the AHMSA fuel costs would increase by some 2.628 billion pesos.

The 1983 fuel combustion rate per ton of steel produced will be as follows:

Heat supplied by purchased fuels:	3.47 Million Kcal/ton	36.4%
Heat supplied by self-generated fuels:	2.12 Million Kcal/ton	22.2%
Heat generated by metallurgical coke:	3.95 Million Kcal/ton	41.4%
Total heat consumption:	9.54 Million Kcal/ton	100%
Net heat consumption:	7.42 Million Kcal/ton	

FUTURE PLANS

Fuel use. Following this same policy, and with the purpose of absorbing the surpluses of coke gas and furnace gas that will be generated in the future, AHMSA has decided to purchase additional equipment to generate steam and electricity for which these surpluses will be purchased as a fuel supply.

The energy distribution balances summarized in Appendices III and IV show the results forecast for a production level of 4.2 million tons/year of steel ingots in the Monclova plants.

Under these conditions, AHMSA's outside fuel costs are estimated to be on the order of 6.857 billion pesos per year, based on average 1983 prices. Again, it should be stressed that if its own fuels were not tapped, fuel costs, estimated on the same basis, would rise by approximately 6.329 billion pesos per year.

Energy distribution control. Due to the large number of energy-consuming equipment in operation, preliminary studies are being prepared for a project involving the purchase and installation of the equipment necessary to implement an "Energy Distribution Center" to complement the present electricity and fuel distribution centers.

Applying the most advanced technology, this system would basically obtain, process and visualize data in its first phase before later applying a distributed digital control system for direct control of the most significant variables.

This distribution center is planned to integrate the control of electricity and fuel distribution - functions which are currently performed separately, though in coordination. It is also planned to include within the proposed system the control of the distribution of other vital fluid inputs, such as: oxygen, nitrogen, water, steam and service air. With this system the capacity and flexibility characteristic of these systems will be fully tapped.

AHMSA cannot discard the other possibilities for savings in the consuming units themselves. To this end, studies have been prepared regarding the installation of heat recovery systems in re-heating ovens and sows.

The installation of this equipment will allow savings of approximately 25% in fuel consumption, the equivalent of 72 million Kcal/hour and 293.8 billion pesos per year, on the basis of current prices of purchased fuels. These projects are at present in the phase of feasibility analysis. (See Flowchart No.6, Appendix V).

Continuous combustion gas analyzers will shortly be installed to monitor the oxygen content of exhaust gases. The next step will be to incorporate these variables into the instrumentation systems to monitor the air/fuel ratio.

This equipment will initially be installed in boilers and slab reheating furnaces.

ENERGY SAVINGS IN COMBINED CYCLES

Five combined cycles of gas turbines and recovery boilers have been installed for operation to date. These boilers use the turbine exhaust gases to produce 143 tons/hour of steam which generates 27,000 kW of electricity. The estimated saving is in the order of 106.7 Million Kcal/hour, representing an annual savings of 438 million pesos at current prices.

A combined cycle began operating in 1959 using an 8,100 kW gas turbine and a 65 ton-per-hour steam boiler (See Flowchart No. 1). The turbine exhaust gases, 317,000 Kg/hour at a temperature of 388°C, are distributed as follows:

79,000 Kg/hour are used as combustion air for the boiler and the remaining 238,000 are mixed with the boiler combustion gases, passing through the economizer to heat the water fed to the same unit. The annual savings with this system are 72 million pesos.

In 1965 another combined cycle was put onstream with a 20,000 kW gas turbine and a 27 ton-per-hour steam recovery boiler. (See Flowchart No. 2).

The gas turbine exhaust gases (470,000 Kg/hour at 300^{o}C) pass to the boiler, mixed with the superheater exhaust gases. The annual savings with this facility are 58 million pesos.

In 1976, a combined cycle began operation using a 14,800 kW blast-furnace gas turbine and a 50 ton-per-hour steam recovery boiler to feed a 10,000 kW steam turbogenerator. (See Flowchart No. 3).

The turbine exhaust gases (631,440 Kg/hour at 400^{o}C) are fed directly to the boiler. The total yearly savings are 148 million pesos.

In 1977 more combined cycles entered service with two 15,500 kW gas turbines and two 39 ton-per-hour steam-recovery boilers to feed a 10,000 kW turbogenerator. (See Flowchart No. 4).

The turbine exhaust gases (420,000 Kg/hour at 390^{o}C per unit) pass directly to the respective boilers. The total yearly savings with this system are 160 million pesos.

The near future foresees the installation of two 56 ton-per-hour boilers that will form a combined cycle with two 24,500 kW gas turbines that recently began operation. With this system it will be possible to recover 83.8 million Kcal/hour, representing a savings of 346 million pesos per year at present fuel prices.

Appendix I

FUEL DISTRIBUTION ALTERNATIVES

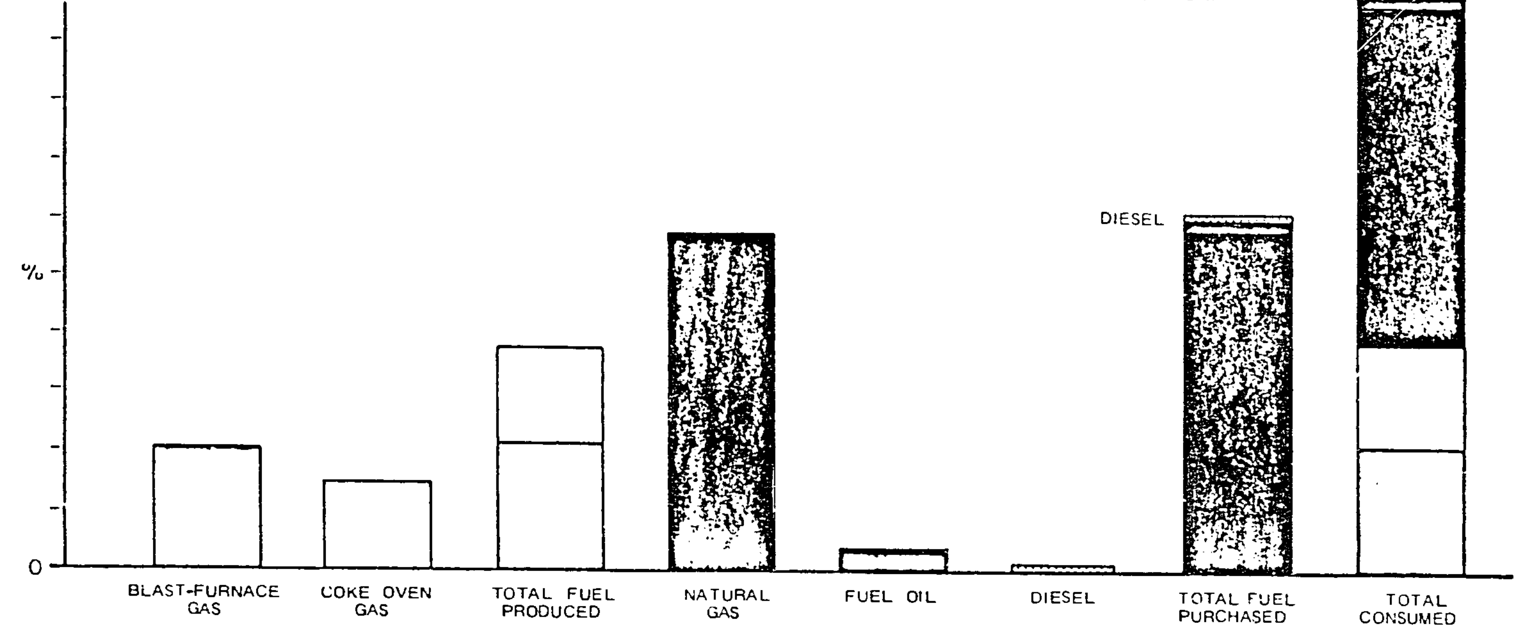
DEPARTMENT	BLAST-FURNACE GAS	COKE OVEN GAS	NATURAL GAS	FUEL OIL	DIESEL
COKING PLANT					
SINTERING PLANTS					
BLAST FURNACE					
STEEL-PLATING H.A.					
STEEL-PLATING B.O.F.		F			
ROUGHING PIT 1					
STRIP FURNACE					
PLATE FURNACES					
ROUGHING PIT 2					
BILLET FURNACE					
WIRE ROD FURNACE					
HEAVY PRODUCTS FURNACE					
ANNEALING FURNACES					
POWER PLANT No. 1					
POWER PLANT No. 2					
POWER PLANT No. 3					
POWER PLANT No. 4					
POWER PLANT No. 5					
POWER PLANT No. 6		F			
MISCELLANEOUS					

(F) FUTURE

Appendix II

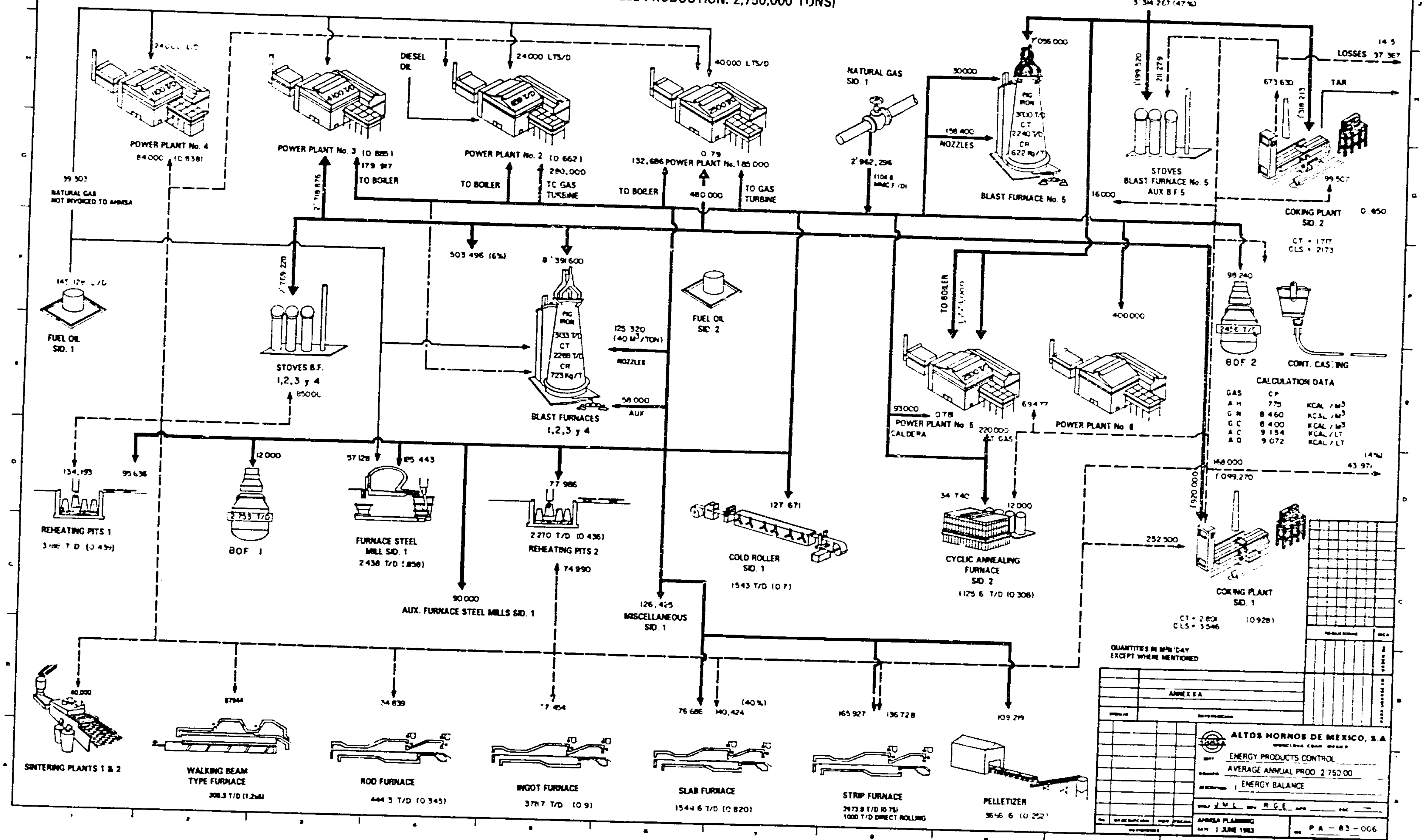
		M3 PER DAY ('000)	KCAL PER DAY (MILLIONS)	KCAL PER TON PER DAY (MILLIONS)	% HEAT
FUEL PRODUCED IN THE PLANT	BLAST FURNACE GAS	11,629	9,013	1.17	21.1
	COKE OVEN GAS	1,631	7,179	0.93	16.8
	TOTAL		16,192	2.12	37.9
FUEL PURCHASED	NATURAL GAS	2,962	25,061	3.27	58.6
	FUEL OIL	145	1,328	0.17	3.1
	DIESEL	20	181	0.05	0.4
	TOTAL		26,570	3.47	62.1
PRODUCED + PURCHASED	TOTAL		42,762	5.59	100.0

FUEL CONSUMPTION BASED ON 2.75 MILLION TONNES OF STEEL PER ANNUM



ENERGY BALANCE SID. No. 1 AND 2

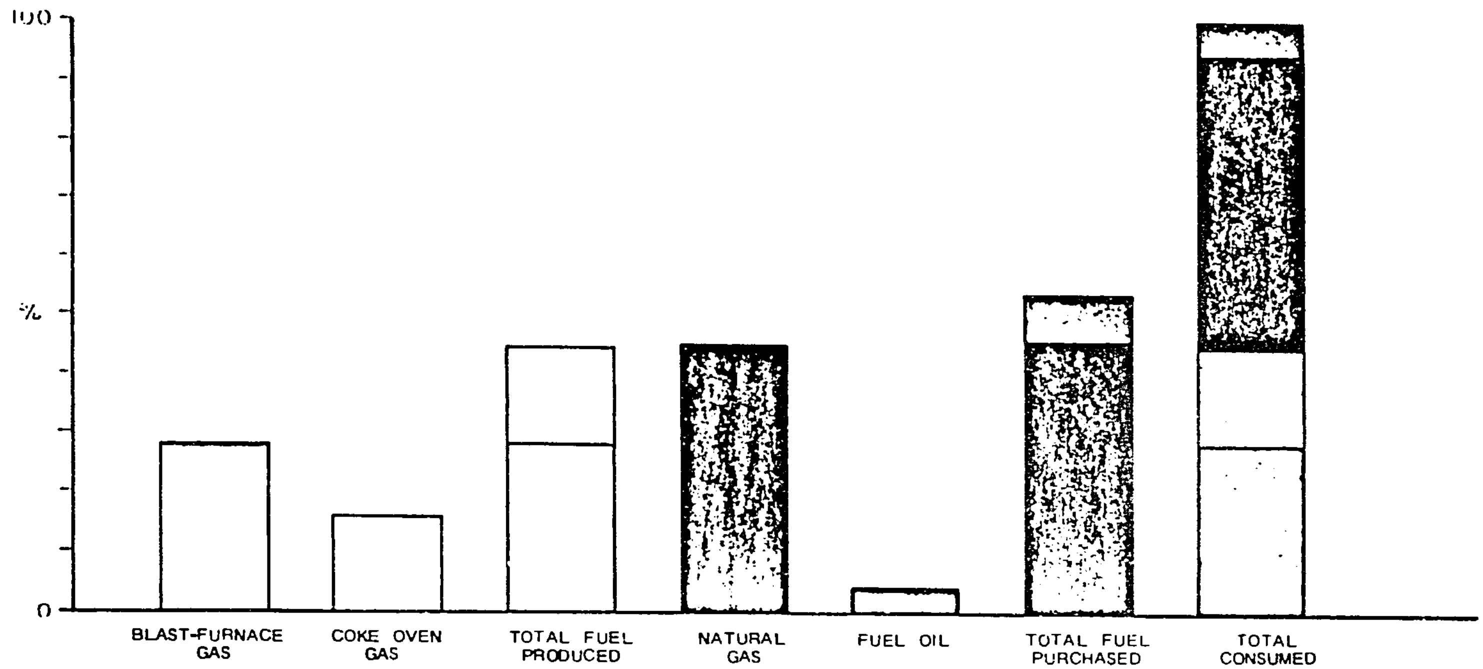
(ANNUAL STEEL PRODUCTION: 2,750,000 TONS)



Appendix III

		M3 PER DAY ('000)	KCAL PER DAY (MILLIONS)	KCAL PER TON PER DAY (MILLIONS)	% HEAT
FUEL PRODUCED IN THE PLANT	BLAST-FURNACE GAS	23,622	18,307	1,59	28.8
	COKE OVEN GAS	2,538	11,167	0.97	17.6
	TOTAL		29,474	2.56	46.4
FUEL PURCHASED	NATURAL GAS	3,530	29,864	2.59	47.0
	FUEL OIL	460	4,211	0.36	6.6
	TOTAL		34,075	2.95	53.6
PRODUCED + PURCHASED	TOTAL		63,549	5.51	100.0

FUEL CONSUMPTION GASED ON 4.2 MILLION TONNES OF STEEL PER ANNUM



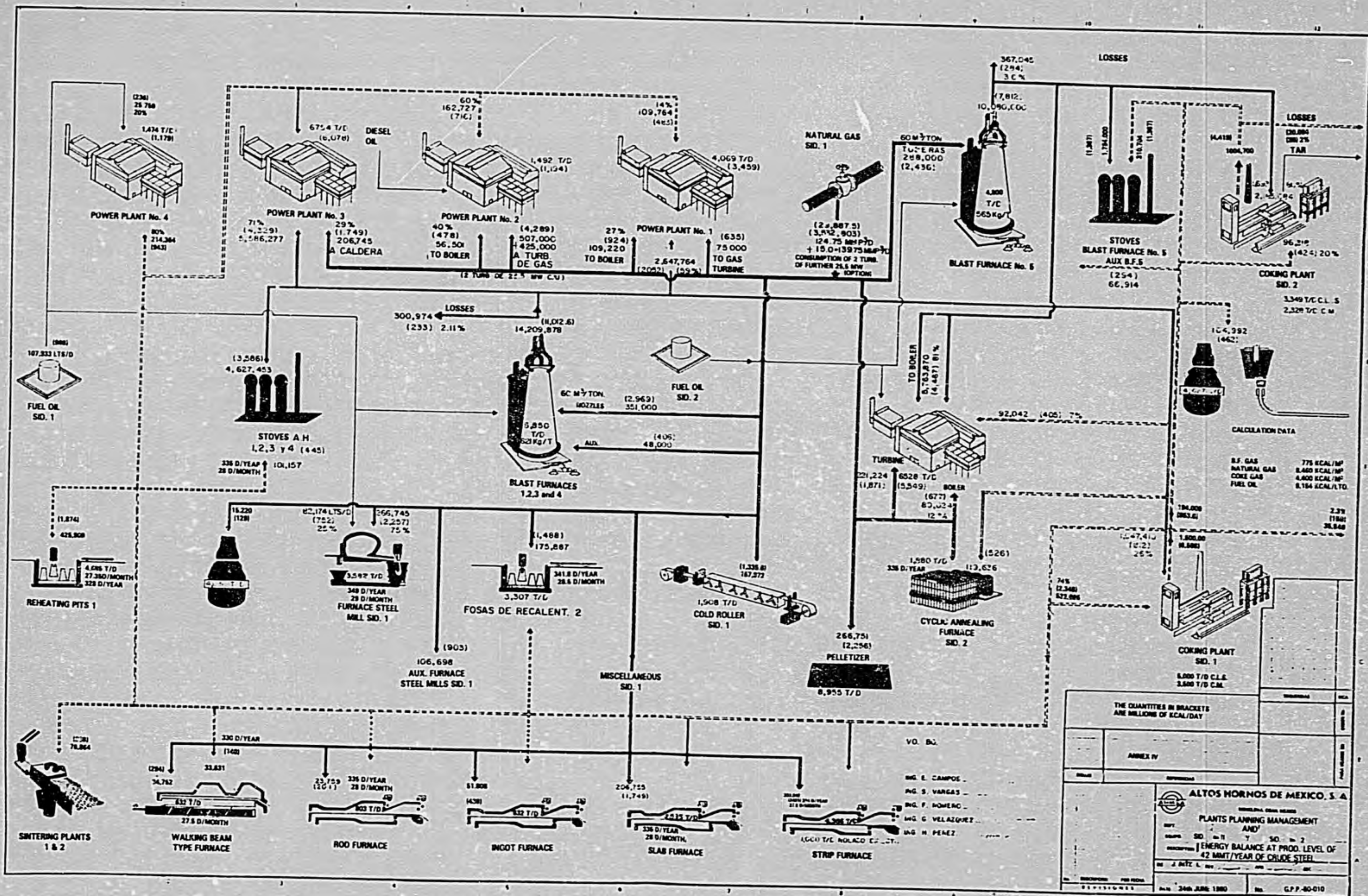
Appendix III

ENERGY SAVINGS

YEAR	DEPARTMENT	TURBINE CAPACITY MW	BOILER TON/HR.	USE OF ESCAPE GASES	SAVINGS IN MILLIONS OF PESOS
1959	POWER PLANT No. 1	8.1	23.2	FURNACE AIR	72
1965	POWER PLANT No. 2	20.0	18.8	STEAM GENERATOR	58
1976	POWER PLANT No. 5	14.8	50.0	STEAM GENERATOR	148
1977	POWER PLANT No. 2	15.5	26.0	STEAM GENERATOR	80
1977	POWER PLANT No. 2	15.5	26.0	STEAM GENERATOR	80
	ACTUAL TOTAL		143.0		438

HEAT RECUPERATION IN (FUTURE) REHEATING FURNACES ANT PITS

DEPARTMENT	NATURAL GAS CONSUMPTION		OUTPUT GAS TEMPERATURE °C	ANNUAL SAVINGS	
	WITHOUT RECUPERATOR	WITH RECUPERATOR		%	MILLIONS OF PESOS
ROUGHING PIT No. 1	221,513	190,501	600	14.0	45
ROUGHING PIT No. 2	175,886	130,507	860	25.8	66
PLATE FURNACE	206,737	153,399	1,100	25.8	77
STRIP FURNACE	283,806	210,584	1,010	25.8	106
			TOTAL		294


POWER PLANT No. 4
POWER PLANT No. 3
POWER PLANT No. 2
POWER PLANT No. 1
DIESEL OIL
NATURAL GAS SID. 1
BLAST FURNACE No. 5
STOVES BLAST FURNACE No. 5 AUX B.F.5
COKING PLANT SID. 2
LOSSES
TAR
A CALDERA
TO BOILER
A TURB. DE GAS
TO GAS TURBINE
FUEL OIL SID. 1
STOVES A.H. 1,2,3 y 4
BLAST FURNACES 1,2,3 and 4
FUEL OIL SID. 2
TURBINE
BOILER
CALCULATION DATA
B.F. GAS 775 KCAL/M³
NATURAL GAS 8,460 KCAL/M³
COKE GAS 4,600 KCAL/M³
FUEL OIL 9,154 KCAL/LTD.
REHEATING PITS 1
FURNACE STEEL MILL SID. 1
FOSAS DE RECALENT. 2
COLD ROLLER SID. 1
PELLETIZER
CYCLIC ANNEALING FURNACE SID. 2
COKING PLANT SID. 1
AUX. FURNACE STEEL MILLS SID. 1
MISCELLANEOUS SID. 1
SINTERING PLANTS 1 & 2
WALKING BEAM TYPE FURNACE
ROD FURNACE
INGOT FURNACE
SLAB FURNACE
STRIP FURNACE
THE QUANTITIES IN BRACKETS ARE MILLIONS OF KCAL/DAY
ANNEX IV
ALTOS HORNOS DE MEXICO, S. A.
PLANTS PLANNING MANAGEMENT
ENERGY BALANCE AT PROD. LEVEL OF 42 MMT/YEAR OF CRUDE STEEL
24th JUNE 1980
G.P.P.-80-010

APPENDIX V

Heat recovery in reheating sows and furnaces.
Based on: Heat Balance, 412 million tons of steel/year.

1. Hot lamination reheating sows.
Installation of heat recoverers to preheat combustion air.

Fuel consumption without recovery	22,513m^3 natural gas/day
Fuel consumption with recovery	190,501m^3 natural gas/day
Exhaust gas temperature	600^{o}C
Input air temperature	30^{o}C
Output air temperature	315^{o}C
Fuel savings (14%)	31,012m^3 natural gas/day
Cost of fuel purchases	$468.83/million Kcal
Total savings/year	$ 44,895.81

2. Reheating sows for light steel shapes.
Installation of heat recuperators to reheat the combustion air.

Fuel consumption without recovery	175,886m^3 natural gas/day
Fuel consumption with recovery	130,507m^3 natural gas/day
Exhaust gas temperature	860^{o}C
Input air temperature	30^{o}C
Output air temperature	425 'C
Fuel savings (25.8%)	45,379m^3 natural gas/day
Total savings/year	$ 65,694,100.00

3. Slab furnace.
Installation of heat recoverers to preheat the combustion air.

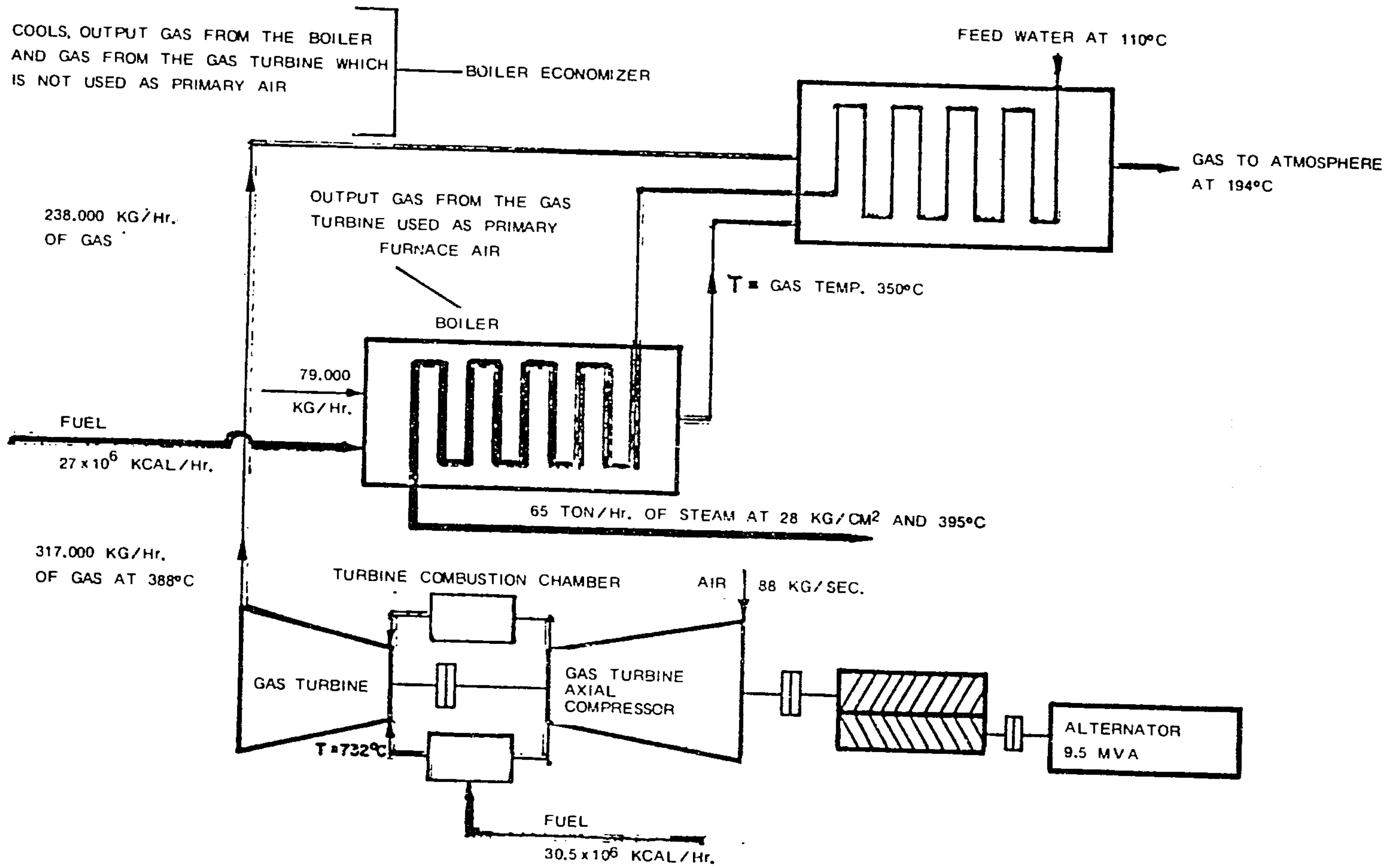
Fuel consumption without recovery	206,737m^3 natural gas/day
Fuel consumption with recovery	153,399m^3 natural gas/day
Exhaust gas temperature	1.100^{o}C
Input air temperature	30^{o}C
Output air temperature	425^{o}C
Fuel savings (25.8%)	53,338m^3 natural gas/day
Total savings/year	$ 77,215,808.00

4. Strip furnaces.
Installation of heat recuperators to preheat the combustion air.

Fuel consumption without recovery	283,806m^3 natural gas/day
Fuel consumption with recovery	210,584m^3 natural gas/day
Exhaust gas temperature	1.010^{0}C
Input air temperature	30^{0}C
Output air temperature	425^{0}C
Fuel savings (25.8%)	73,222m^3 natural gas/day
Total savings/year	$106,012,379.00

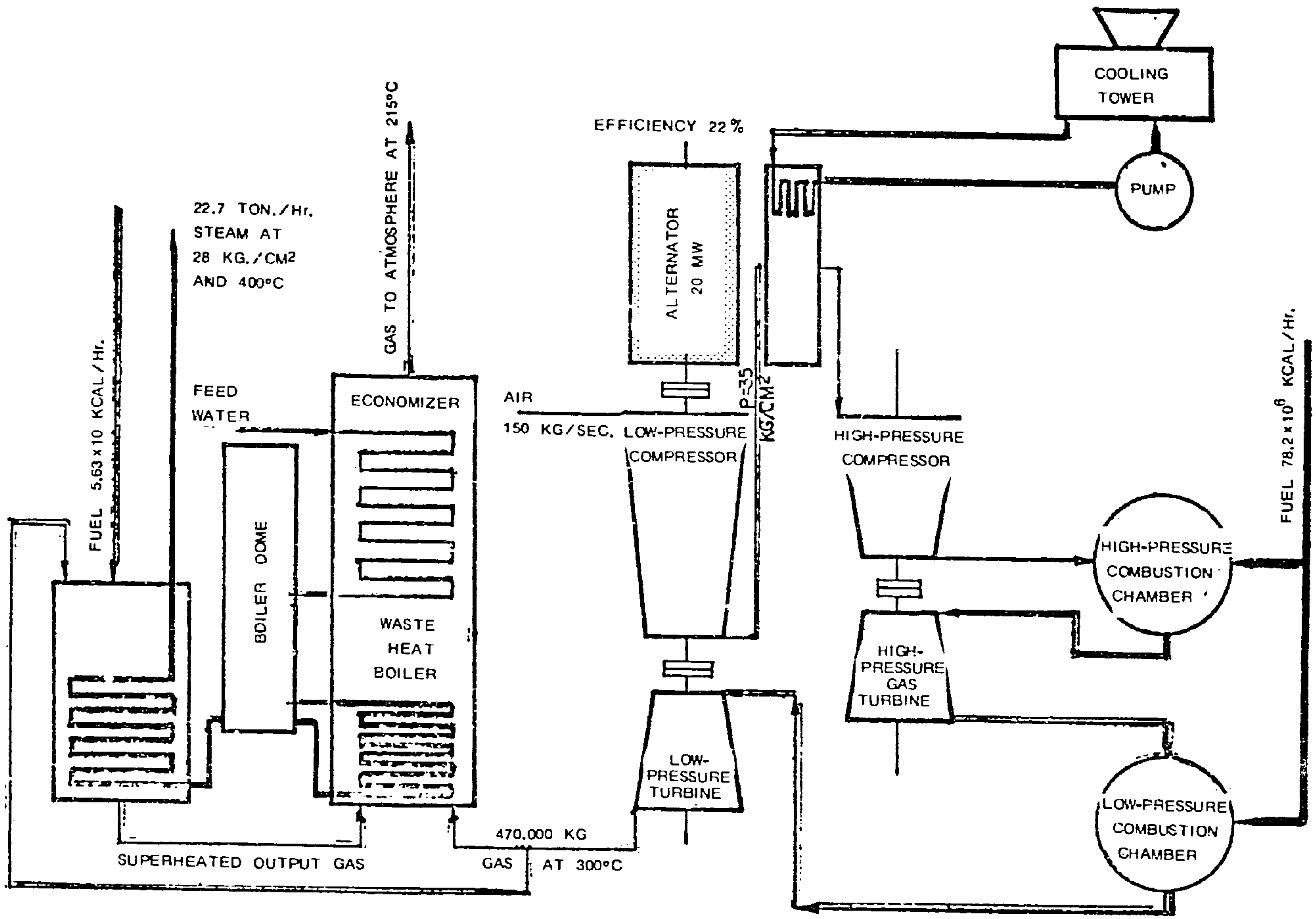
These figures are based on the average daily fuel consumption for a yearly production of 4.2 million tons of steel.

The grand total for these four facilities represents a savings of $293,818,104.00/year.



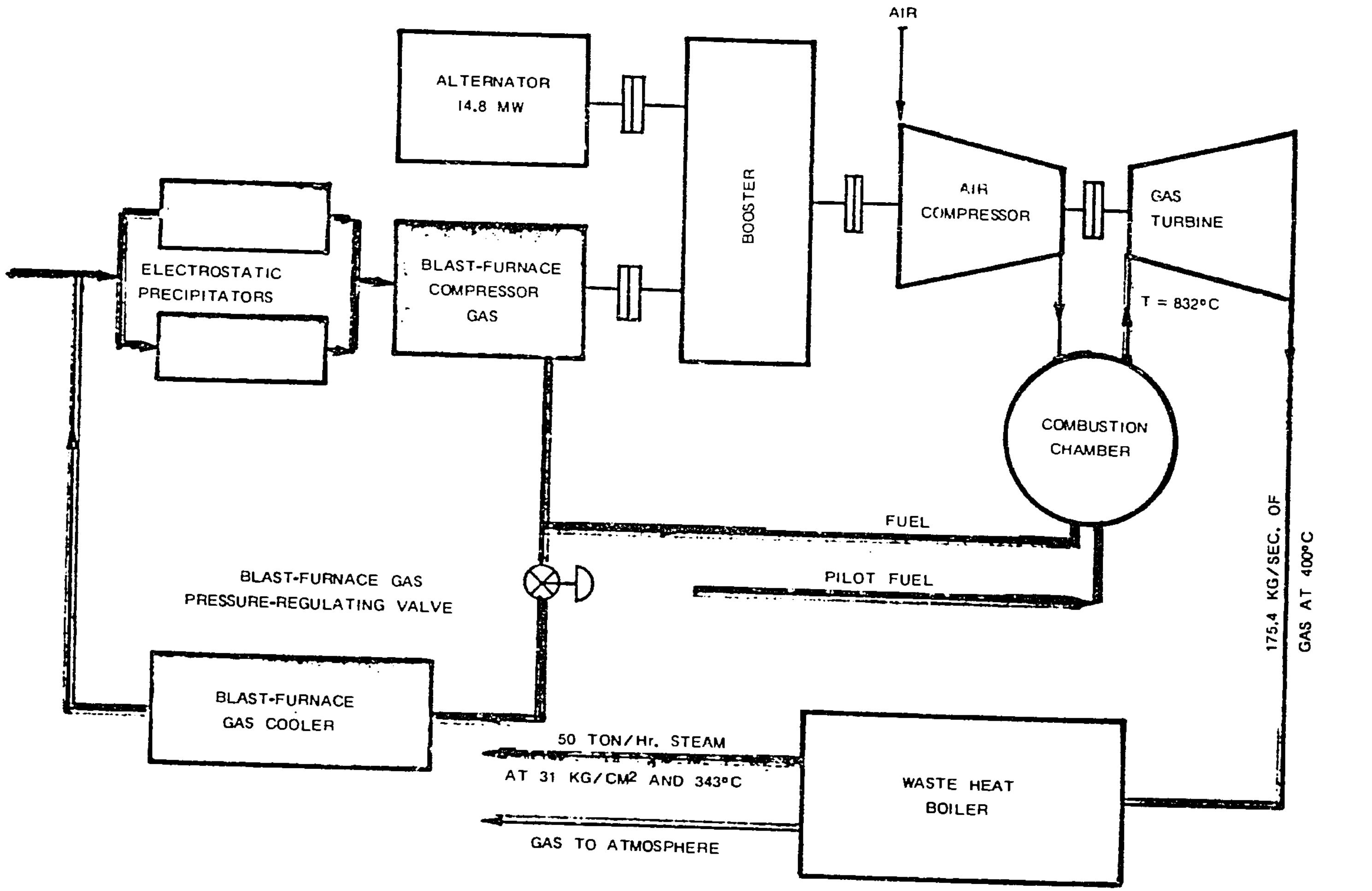
COMBINED CYCLE - GAS TURBINE WITH HEAT RECOVERY - POWER PLANT No. 1

Diagram No. 1



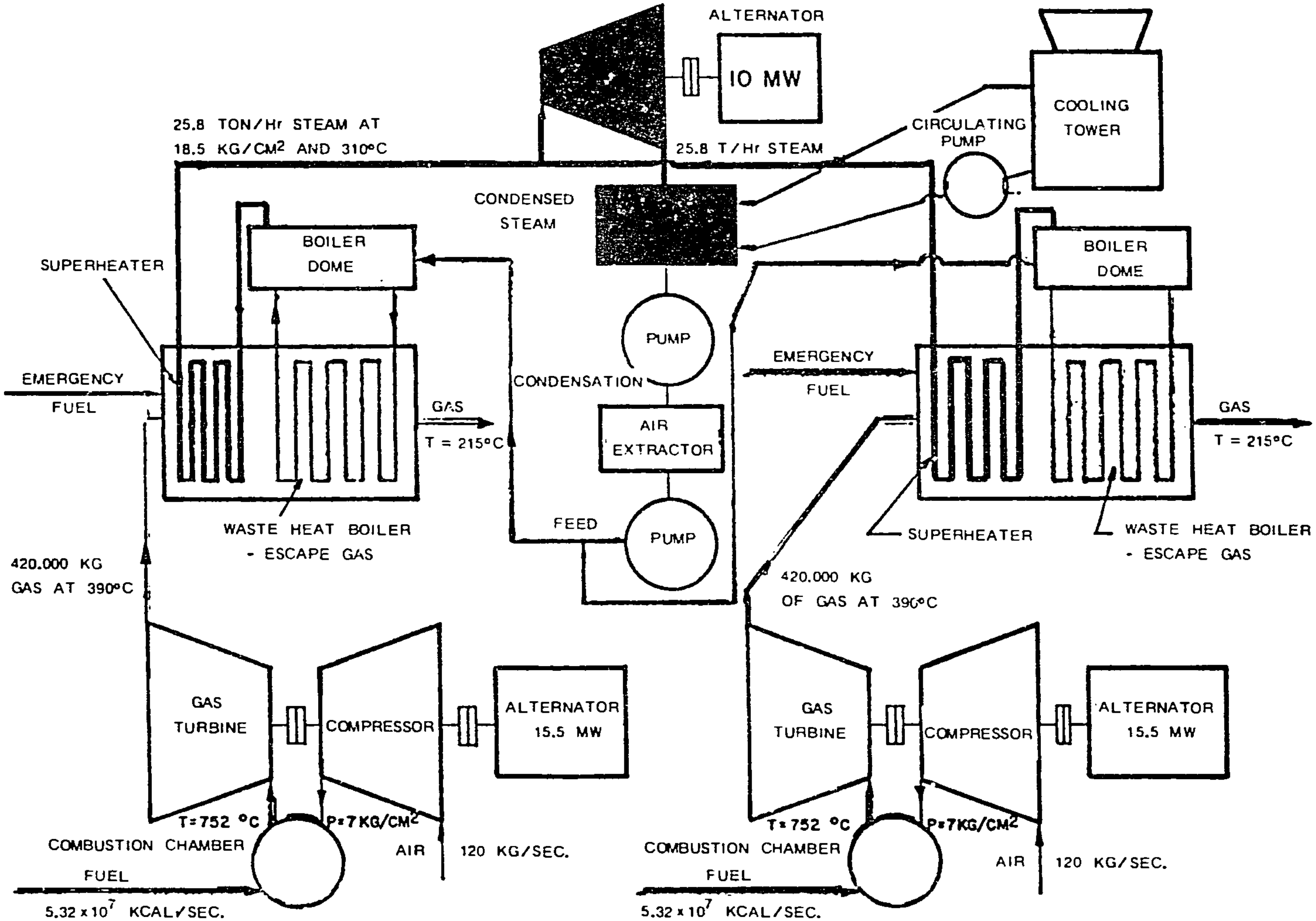
COMBINED CYCLE - GAS TURBINE WITH HEAT RECOVERY
- POWER PLANT No. 2

Diagram No. 2



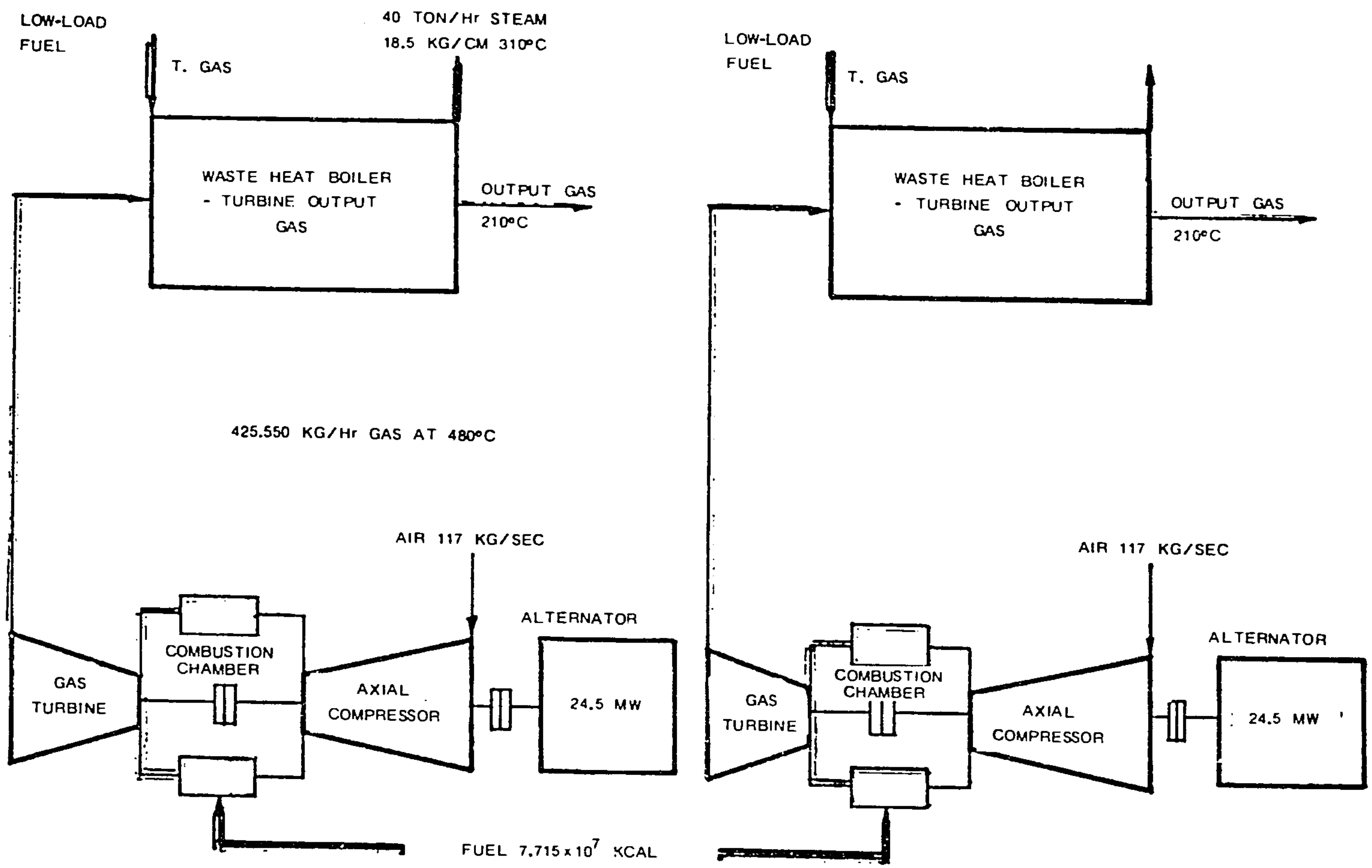
COMBINED CYCLE - GAS TURBINE WITH HEAT RECOVERY
- POWER PLANT No. 5

Diagram No. 3



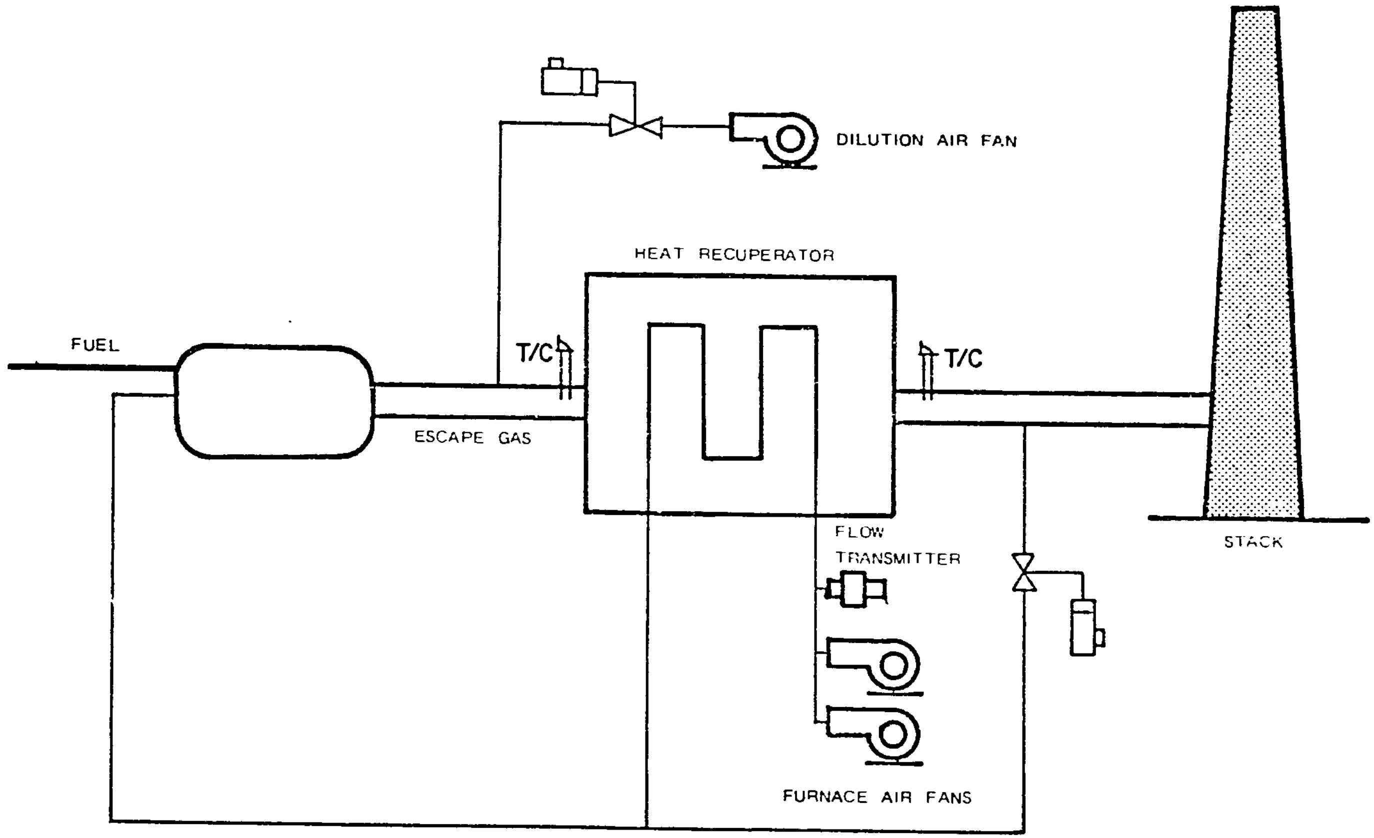
COMBINED CYCLE - NATURAL GAS/DIESEL TURBINES WITH
HEAT RECOVERY - POWER PLANT No. 2

Diagram No. 4



COMBINED CYCLE - GAS TURBINE WITH HEAT RECOVERY
- POWER PLANT No. 6

Diagram No. 5



HEAT RECOVERY IN REHEATING FURNACES AND PITS

Diagram No. 6

RATIONALIZATION OF CONSUMPTION IN GREAT COPPER MINING
"Energy in Codelco-Chile"

Hugo Bonomelli C.
Technical Manager, Codelco-Chile

Valerio Rioseco van C.
Assistant Engineering Manager, Codelco-Chile

The "Corporación Nacional del Cobre del Chile" or National Copper Corporation of Chile (CODELCO-CHILE), created by Decree-Law No. 1350 of February 1976, owns the mines, plants and operations that constitute the "Gran Minería del Cobre" (Great Copper Mining), nationalized in 1971. The total 1982 output of the four operative divisions (Chuquicamata, El Salvador, Andina and El Teniente) amounted to 1,033,000 tons of copper.

From the energy point of view, the Chilean copper mining industry-- to which Codelco-Chile contributes about 86% of the production-- used 6.7% of the total energy products consumed by the country in 1981, including 20.3% of the fuel oil and 31.7% of the total electric power generated in Chile.

Codelco-Chile is the country's major autoproducer of electricity, with a production amounting to 1,625,755,655 kWh in 1981, and to some 1,450,000,000 kWh in 1982, i.e., 15.3% of total electric power generation.

Regarding types of generation, it is worthwhile to note that the Corporation's hydro power represented 5.2% of this type of energy output in Chile for 1981. That meant that 24.4% of its own consumption was supplied by power generated in its four hydroelectric plants.

On the basis of the above-mentioned explanations, it can be observed that Codelco-Chile (and the copper industry) is not only the greatest industrial consumer of energy, but also an important autoproducer of electricity.

Both features, added to the fact that fuel and energy purchase amount to approximately 15% of total production costs, including depreciation and amortization, financing expenses and sales taxes, oblige the Corporation to act-- either to save on energy consumption or to substitute energy forms, seeking the most economical ones for processes and operations.

Energy Consumption in Copper Extraction Metallurgy

Before analyzing energy consumption, and the actions taken towards rationalization and savings, it is useful to indicate global characteristics and alternatives in copper production. For that purpose, the main processes for recovering copper from sulphide ores are shown in Fig.1. Approximately 90% of the copper originates in sulphide, which is mainly produced from concentrates, by means of pyrometallurigical processes and technology.

The recovery process generally consists of the following four steps:

a) Concentration by flotation

b) Roasting (optional)

c) Smelting of matte (in blast furnaces, reverberatory furnaces, electric furnaces, or flash-smelting furnaces)

d) Conversion to blister copper

Some processes combine the b), c) and d) stages in one continuous process.

The final product is "blister copper" which must be refined (by fire or electrically) for end uses.

Fig. 2 shows the hydrometallurgical processes for copper extraction from oxidized ores. Copper can also be found in nature, as carbonates, oxides, silicates and sulphates which cannot be concentrated efficiently by flotation and which are treated by means of hydrometallurgical process and technologies, e.g., by means of leaching with sulphuric acid, followed by precipitation or electro-winning from the solution.

The current upward trend for energy requirements in the copper mining industry is a consequence of:

a) A continuous grade decay of present ore bodies, which entails transportation, crushing, milling and concentration of larger quantities of ore to produce one kilogram of copper.

b) An increase of ore hardness, which implies greater consumption of energy in comminution.

c) An increase in horizontal and vertical transportation, due to deeper underground mines and open pits.

d) A worse waste/ore ratio, generating a greater amount of material handling for each ton of ore removed.

These trends are a permanent challenge for the substitution of energy sources of high value by others of lower cost or more efficiency and for a reduction in the specific consumption of fuel and energy in production processes and operations.

It should be pointed out (only for the sake of illustration) that energy consumption in the processes is, percentage-wise, as follows:

Mine and concentrator	53.6
Smelter	33.9

From these values whose validity is relative and limited, it can be inferred that the actions to be taken regarding savings, rationalization and substitution of energy must be concentrated on the smelter, concentrator and mine areas; and only when these fields have been substantially covered, will it be convenient to worry about conversion, anode preparation and electrolytic refining.

As a consequence of the oil crisis that hit the industrial world with great intensity during 1976-1979 (the first price rise took place in 1973), Chile was forced to pay high prices for oil while international copper prices were at a very low level (55.94 - 63.61 cents of the U.S. dollars were average values per pound of copper); and so, the Corporation, which was beginning to act as the entity that grouped the productive divisions, undertook immediate action to diminish energy consumption and to replace some energy sources by others of lower cost.

During the early years, division management dealt with energy "waste" and tried to create a consciousness of the need for controlled consumption and rational use of energy.

In general, these activities had to be carried out with small investments, due to restrictions imposed on Codelco-Chile as a result of the economic situation.

By 1978 local action was considered complete; and as a consequence, to make substantial advances and obtain an adequate choice of energy conservation alternatives, a decision was made to undertake integrated actions within the development plans of each division, geared to optimizing corporative benefits. At the same time, systematic action was proposed to standardize information about energy uses, yields, and consumption, as well as the diagnoses and identification of "Energy Conservation Opportunities" (ECO's). Some examples of these measures are given in Appendix 1, for the Chuquicamata division.

The actions taken to attain the indicated objectives can be summarized as follows:

a) Execution of "Global Studies on Long-range Development" for the Chuquicamata, Salvador and El Teniente divisions.

b) Preparation of a study dealing with energy rationalization for the Chuquicamata division and identifying ECO's, which could represent an overall potential saving of up to 24% of the division's fuel consumption (including the Tocopilla power station). Excluding ECO's where significant investment is required, a cost decrease of up to 8% could be obtained by means of fuel oil, diesel oil, kerosene and gasoline savings.

c) Engineering study on "Research on Power Supply Alternatives for Chuquicamata" (including 1,600 km of transmission lines). The study concluded that:

- Economically speaking, the supply of the forecasted electric demand of Chuquicamata, together with the first and second regions (northern part of the country), is not large enough to justify interconnection with the national grid from the central zone of the country (transmission systems of 345 kV-AC and ± 140 kV-CC for the present situation and ± 280 kV-CC for the future were analyzed).

- The generating units to be installed at the Tocopilla power station could be oil- or coal-fired, where the use of coal is justified for relatively low value of the money.

d) Feasibility study on the use of Chilean coal as the main fuel for Tocopilla. This study was originally performed for bituminous coal from the Gulf of Arauco and later revised, in 1981, for use with Magellan (sub-bituminous) coal.

e) Installation of a new 72-MW generating unit (No. 12) capable of burning fuel oil or Magellan coal and allowing for the replacement of some very inefficient older units (1914-1927) with high consumption (127.2 g/MJ burning fuel oil). The new unit's consumption is 69,3 g/MJ with fuel oil and 151.9 g/MJ with Magellan coal.

This unit is now complete and will definitively be put onstream in June 1983.

f) Completion of a project to change the frequency of the Salvador division from 60 Hz to 50 Hz, which made possible the electric power supply from the national grid, beginning in August 1981.

g) Analysis and prefeasibility study on hydroelectric generation from the Aconcagua river, for the Andina division.

h) Analysis and prefeasibility study on hydroelectric developments on the Cachapoal river for the El Teniente division.

According to the conclusions of the study, a contract for electricity supply from the national grid was negotiated with ENDESA (the national electric power company).

i) Regarding the standarization of information referring to energy use, consumption and efficiency, "Guidelines for Energy Analysis in the Division" were issued in July 1980, as a result of corporative meetings on "Energy Coordination". These periodical meetings began in 1979.

Appendix 3 provides some examples of actions and projects already executed and others to be undertaken, aimed at energy savings and substitution in every operative division.

Future Actions

As has been stated herein, Codelco-Chile has carried out global studies on future developments for each of the divisions, as well as on subjects related to processes, operations and energy supply. The studies analyzing supply and demand include studies on the use of energy (heat and electricity) recovery from the processes and consider alternative conventional and non-conventional energy sources (advanced, according to some studies).

The energy analysis approach of Codelco-Chile follows two directions:

a) Technological development and

b) Rationalization - optimization.

Technological development

Codelco-Chile has forced its technological development not only on the substitution of current processes and foreign technologies- which would generally entail a complete change in existing installations with large investment- but has also, to a great extent, been able to design its own technologies for increasing the production capacity with low capital costs, while reducing specific fuel consumption to significantly lower values.

As one example of this policy, Codelco-Chile has implemented the use of oxygen in different stages of the smelting process. Thus, the so-called "Modified Teniente-type Converter" (MTC), which by means of an oxygen-air mixture in the blowing step disminishes the gas produced, reduces heat losses and permits partial direct smelting of concentrates without additional fuel in the converter.

The use of oxygen-fuel burners located in the reveberatory furnace roof, which changes the heat system to convection, permits the utilization of the burner wall as a load wall, resulting in a doubling of the furnace's smelting capacity and a reduction in specific fuel consumption.

Figure 3 shows evolution in fuel and electric power consumption, and the productivity of the Caletones Smelter where the technology was developed.

The first Modified Teniente-type Converter, whose installation is now underway at Chuquicamata, will be commissioned by the end of 1983.

Further development of oxygen-coal burners and oxygen-concentrate burners has been undertaken, and they are now in a pilot testing stage.

It must be mentioned that the two ENAMI smelters have decided to adopt MTC converters too.

In addition to these first technological developments, Codelco-Chile is continously evaluating the possibilities that foreign technology could offer to decrease costs.

The impact of energy on costs leads to particular attention to energy savings and minimal specific consumption. An example of this is the purchase of technology and know-how for in situ leaching from the Occidental Mineral Corporation, to be partially applied in the Chuqui-Sur mine.

This technology consists of introducing acid solutions into the ore body at high pressures, without removing the ore, followed by recovery, purification and concentration through solvent extraction and final electrowinning.

If this technology could be successfully applied in Chuqui-Sur, the energy savings appear evident, because neither ore extraction, nor crushing, milling and smelting are needed, although considerable energy is consumed in solution pumping, drilling and electrowinning. This technology is going to be tested on a pilot scale in the near future.

Rationalization - optimization

In order to rationalize and optimize energy consumption, all the divisions have installed automatic controls at different stages in their operations (tertiary crushing and milling), to avoid overgrinding, The savings in these areas amount to more than 5%.

Different types of mill linings have been tested, such as that known as the ASL, which moves the material in a spiral pattern, reducing ball consumption and, accordingly, the energy required (10% savings).

In the mine, efforts at reducing energy consumption- among which the field of loading and transportation is the most important- have indicated the advantages of using "giant" equipment as a means of energy optimization. Following the same concept, regarding flotation cells, Codelco-Chile has considered the use of "giant cells" in all recent concentrator expansions, and even contemplates a progressive replacement of existing cells by giant ones. Also, the cell impellers are being changed for new models of higher efficiency.

Some cases of consumption rationalization are described in Appendix 1, such as peak demand control (which could involve energy of higher cost); programmed shutdown of equipment during low utilization periods, etc., using micro designs for energy savings.

The shift to alternative energy could be represented by the new 72-MW unit of Tocopilla, designed for coal or oil firing; by the oxygen -coal burners design; and by the use of solar energy for water heating and space heating in the workers' dressing rooms and other installations.

A very important project of energy rationalization and conservation has been the interconnection of the Salvador division with the national grid, replacing a power plant with a very high thermoelectric conversion factor (over 3000 kcal per kWh). Besides, the change in the frequency of the electric power system at Salvador included improvements in the overall system at the industrial and domestic centers of Salvador and Petrerillos.

We hope that this brief summary will have given at least an idea of some of the projects and actions developed by Codelco-Chile in the area of energy conservation and rationalization; and in concluding, we would like to point out that this subject is always present as one of the most important factors in any project of the company.

FIGURE No. 1

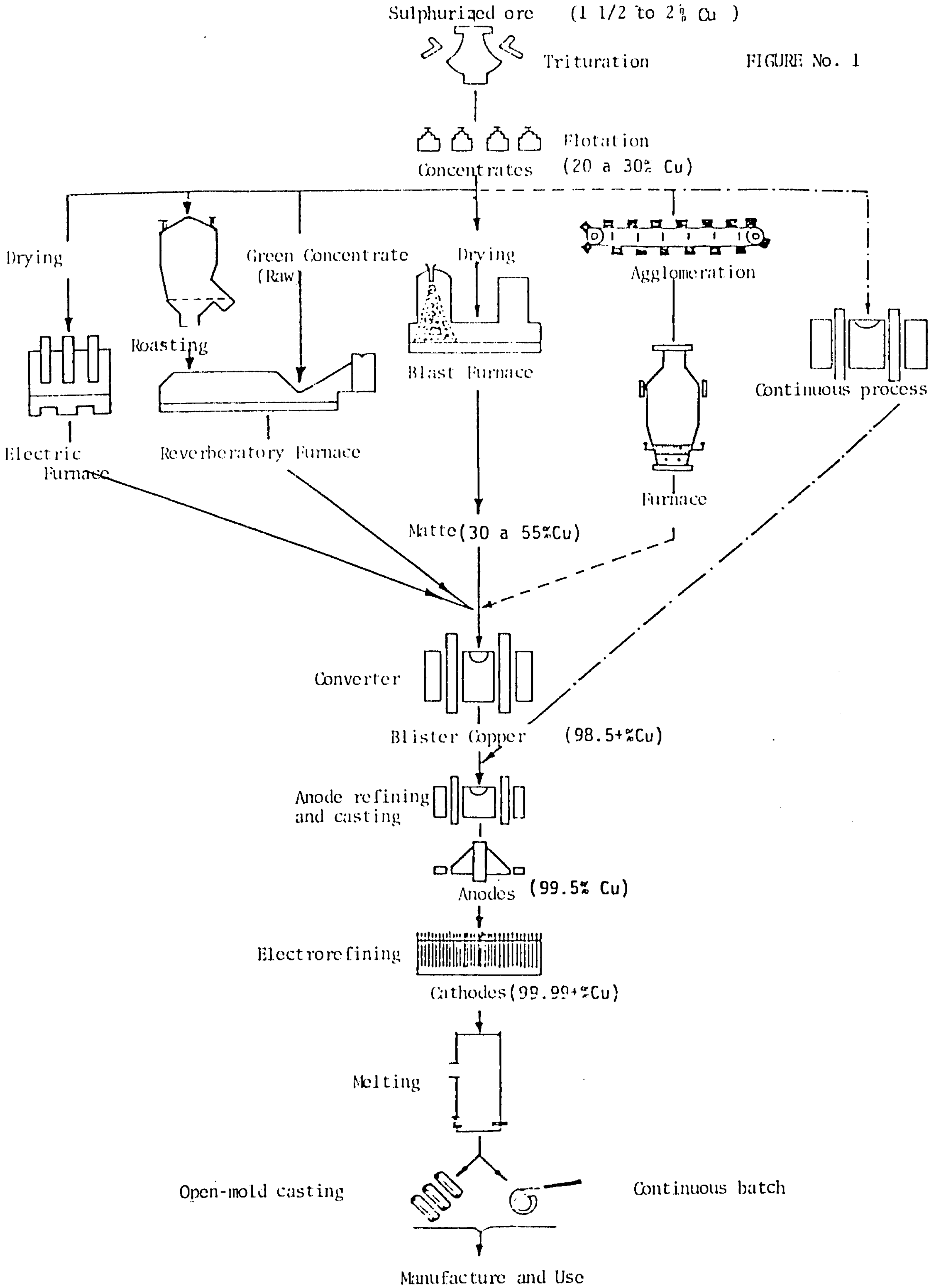
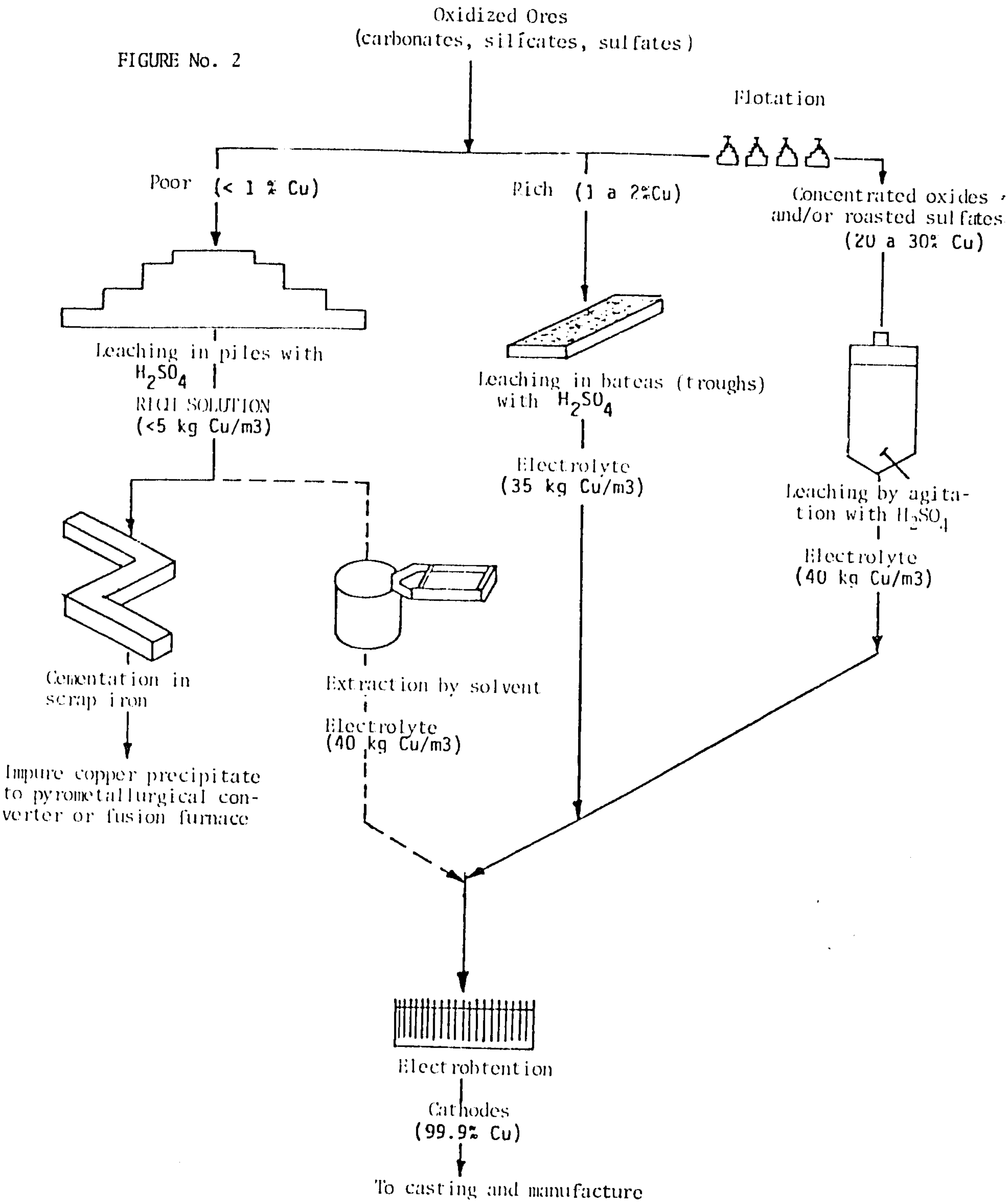
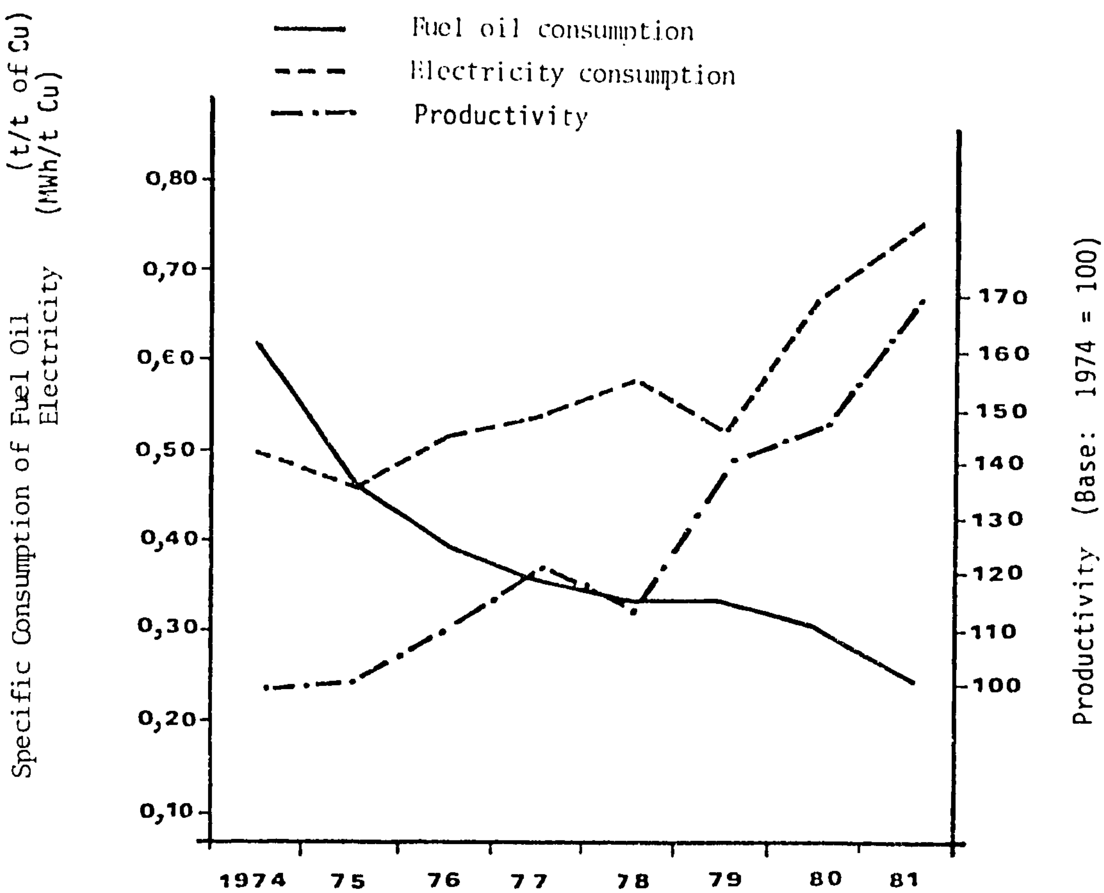

Sulphuriaed ore (1 1/2 to 2% Cu)
Trituration
Flotation
Concentrates (20 a 30% Cu)
Drying
Green Concentrate (Raw)
Drying
Agglomeration
Roasting
Blast Furnace
Continuous process
Electric Furnace
Reverberatory Furnace
Furnace
Matte(30 a 55%Cu)
Converter
Blister Copper (98.5+%Cu)
Anode refining and casting
Anodes (99.5% Cu)
Electrorefining
Cathodes(99.99+%Cu)
Melting
Open-mold casting
Continuous batch
Manufacture and Use

FIGURE No. 2



Principal Processes for Extracting Copper from Oxidized Ores

FIGURE N° 3


Fuel oil consumption
Electricity consumption
Productivity
Specific Consumption of Fuel Oil (t/t of Cu)
Electricity (MWh/t Cu)
0,80
0,70
0,60
0,50
0,40
0,30
0,20
0,10
Productivity (Base: 1974 = 100)
170
160
150
140
130
120
110
100
1974
75
76
77
78
79
80
81

APPENDIX 1

Energy Conservation Opportunities (ECO's): Some Examples from the Chuquicamata Division.

ECO's are defined as those potential situations that would permit energy conservation in a short term, as a consequence of the information-gathering process as regards the energy situation in the Chuquicamata complex.

Those situations that involve medium- and long-term actions, or investment projects that require engineering studies, options developments or extensive studies on the use and management of energy, are not included or defined as ECO's.

ECO's can be implemented mainly through:

- Review of operational practices
- Definition of energy administration programs
- Small, obvious or short-term implementation investment.

Examples of some identified ECO's are:

1.- Tocopilla thermoelectric plant.

1.1 Automatic cleaning of condensers. Every 15 days half of each condenser was taken out of service for manual cleaning, using rubber "pigs". Automatic cleaning (MANN or AMERTAP, for instance) of the pipes will improve the average heat transfer coefficient, reduce backpressure, increase available power, and eliminate the need to shut down the condensers for cleaning.

1.2 Fuel-return tank insulation. One of the Bunker C tanks is used to store the oil surplus returned from the burners. Proper insulation of this tank will permit effective energy conservation.

2.- Electrical system.

2.1 Electrical dispatch to cut down on peaks.

During peak periods it is necessary to operate the expensive gas turbines in Tocopilla (141.7 g/MJ of diesel oil).

The dispatch system should be established in the substation that ties in the energy generated at Tocopilla with that from Chuquicamata. A computer model simulation available in the Engineering Department could be used.

2.2 Substation A Transformer.

Power transformers 1-4 of this substation, manufactured in 1914, are much less efficient than the modern ones. The first suggestion was to measure their efficiency and estimate their replacement cost. In addition, the star-star connection generated third harmonic voltages in the external circuit. It is necessary to measure this voltage before connecting the bank of capacitors that will be installed in this substation.

2.3 Motor-generator sets and rotary current converters.

Substation A has 17 M/G sets installed for DC supply. An analysis is required before their replacement by static converters (20% more efficient), considering, too, that their efficiency curves show a dramatic drop when the load factor decreases.

2.4 Tocopilla-Chuquicamata transmission lines.

In 1978 the total energy losses in the three circuits amounted to 6.1%. A bank of 100-MVA capacity in substation A is being installed so as to increase transmission capacity and improve the power factor. Also, it has been proposed to study three options for increasing transmission capacity: a fourth circuit, an increase in transmission voltages, and shunt or series compensation.

3.- Mines

In this case we can cite the following ECO's:

3.1 Voltage of electrical input

3.2 Capacity of electrical shovels versus energy consumption

3.3 Alternative fuels for ore trucks

3.4 Reduction in yard lighting

3.5 Parking regulations for large trucks

3.6 Fuel consumption of trucks

3.7 Electric trolley for trucks

3.8 Use of crushers and conveyor belts for sterile transportation

3.9 Truck dispatch system for Chuqui-Sur mining operations

3.10 Recovery of used lube-oil

3.11 Recycling of used tires

4.- Concentrator

4.1 Primary crusher operation. Due to the fact that this crusher, with an induction motor of 500 HP, has long idle periods with a consumption of 60 kWh, a communication system was proposed to tie in the mine with the crusher station and permit shutdown during lunch time occasions where more then one hour of idle time is anticipated.

4.2 Secondary and tertiary crusher programming.

4.3 Power factor adjustment in mill motors.

4.4 Flotation-cell motor replacement.

4.5 Flotation-cell blower improvement.

4.6 Energy consumption optimization in milling operations.

4.7 Steam consumption in molybdenite plant. The moly dryer steam condensate is returned to the thermoelectric plant instead of being vented.

5.- Smelter

5.1 Brickwork rebuilding in the firebox of dryer mumber one.

5.2 M/G set efficiency.

5.3 Heat revovery from the anodes cooling tanks. Approximately 81.3 TJ (19.4 billion kcal/year) are absorbed by the Bosh tanks to cool off anodes.

The partial use of this heat in the personnel dressing rooms is proposed.

5.4 Heat recovery in the anodes furnaces, proposed for use in the concentrate dyers.

5.5 Heat conservation in the anodes.

5.6 Reduction in the amount of recirculating scraps.

6.- Chuquicamata Thermoelectric Plant

6.1 Replacement of evaporators by demineralizers.

6.2 Electric drive for auxiliary equipment.

6.3 Circulation system of cooling water.

6.4 Operation of cooling towers.

6.5 Steam extraction for some processes.

It has been proposed to get steam from a high-pressure extraction point of the turbines instead of the one from the main steam line, for use in the molybdenite dryer, heating fuel oil for the smelter furnaces and also atomization of that fuel.

6.6 Reduction in condensate losses in the moly plant.

6.7 Use of insulation in the moly plant steam line.

6.8 Implementation of thermoelectric plant.

6.9 Major overhaul of turbogenerator.

6.10 Compressor for general use and implementation.

6.11 Condensate control.

A condensate balance is proposed, together with the present production and distribution of steam and distilled water, in order to account for the unreturned condensate; undoubtedly, the accounting, study and justification of the unreturned condensate must increase efficiency and promote energy savings.

APPENDIX 2

Guidelines for Energy Analyses in the Divisions

This document is a guideline for the preparation of energy analyses in each division. It must be reviewed as a necesssary preliminary stage, in order to make homogeneous the information that will be processed annually to obtain comparative indexes within each division and at the corporate level.

Since these are only guidelines, the level and type of information should be adjusted to the particular conditions of the processes in each division.

The following tables shall not be used as questionnaires to be filled out; they indicate only the information level that must be prepared, in the form of simplified tables.

Production and consumption data should be annual and should be compared to the year 1979 as a reference base, for all energy conservation analyses and projections of future technological improvements in the field of energy, in the divisions.

1.- General Data on Installations

1.1 Geographic location:

1.2 Description of installations. Production process diagram.

1.3 Energy use by process.

1.4 Raw material consumption.

1.5 Activity level and production policy.

2.- Energy Supply Sources

2.1 Fuels.

2.2 Electricity.

2.3 Steam.

2.4 Own energy production.

2.5 Unused residual heat.

2.6 Other sources not indicatedabove.

3.- <u>Thermal Analysis of Installations</u>

3.1 Analysis and preparation of individual thermal balances for the different processes (Appendices A & B).

3.2 Functional distribution of energy consumption.

3.3 General scheme of energy flow utilization. Efficiency of energy use.

4.- <u>Specific Consumption and Costs</u>

4.1 Energy consumption per unit of production.

4.2 Incidence of energy in final cost.

4.3 Influence of fuel savings programs on costs.

5.- <u>Final results</u>

5.1 Analysis of energy utilization and results.

5.2 Possibility of improvements in energy use efficiency.

5.3 Financial returns on proposed improvements.

APPENDIX A

Units of Analysis

A.1 Introduction

A.2 Description of production processes

A.3 Basic operations

A.4 Production process diagrams

A.5 Analysis of basic operations

A.6 Summary of yearly consumption of the different processes.

APPENDIX B

Services

B.1 Introduction

B.2 Steam production

B.3 Steam distribution and condensate recovery

B.4 Compressed air

B.5 Refrigeration system

B.6 Lighting

B.7 Air conditioning

B.8 Summary of yearly consumption of the different services.

APPENDIX 3

Some examples of energy-related actions and projects in the divisions of Codelco-Chile can be used to show the diversity of actions being undertaken in the field of energy conservation.

The list that follows is only for the sake of illustration; it is neither complete nor systematic:

1.- <u>Chuquicamata Division</u>

- Lighting modifications (to sodium bulbs)
- Dust control at the crushing plant, avoiding use of high-pressure compressed air.
- Rationalization of the compressed air network.
- Better use of natural light in industrial buildings.
- Use of residual heat from the refining furnaces as fuel for concentrate dryers.
- Electrolytic cells covered with anti-evaporation wrappers.
- Hydraulic actuators in reverberatory furnace doors; redesign of burner; use of heat exchangers.
- Replacement of heat-exchanger pumps at Refinery No. 2.
- Reduction in distance of electrorefined cathodes in electrodes.
- Blower control automation at the concentrate smelter.
- Replacement of electric transformer at the oxide plant.

- Heat recovery from the compressors' cooling water.

- Boiler economizer at the refinery.

2.- Salvador Division

- Installation and commission of a new turbine at the Montandon hydro power plant, with an increased generating capacity of 500,000 kWh over the previous one. This was part of the project "Change in Frequencies and Interconnection to the National Grid".

- Replacement of diesel oil by fuel oil in the reduction process of the anode furnaces.

- Introduction of payments for domestic consumption (which formerly was free at the division), in order to regulate and rationalize the consumption of electricity and fuel.

- Installation of electricity meters in the different industrial areas, in order to identify zones of high consumption and to facilitate control.

- Crushing, milling and flotation automation in order to optimize concentrator production and reduce energy consumption.

- Use of the compressor cooling water as heating media for the salt removal plant and for the workers' dressing rooms.

3.- Andina Division

- Automated demand control that shuts down equipment according to a programmed sequence.

- Change from diesel oil for fuel oil for the concentrate dryer.

- Use of air compressor residual heat for ventilation air heating.

- Use of sodium bulbs in the lighting system on the yards and in underground areas.

4.- <u>Teniente Division</u>

- Improvements in secondary classification at Sewell (to avoid overgrinding).

- Improvements in oxygen, air and steam control.

- Replacement of synchronous capacitors by static ones.

- Reduction in number of motors at the Sewell flotation plant.

- Modifications in the electric control circuit of cooling jacket pumps at the Caletones smelter.

- Increased marginal output from hydraulic generation.

- Optimization of filtration and drying processes.

RATIONAL USE OF ENERGY IN THE NON-FERROUS METALS INDUSTRY

(OTHER THAN ALUMINIUM)

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INTRODUCTION

1. The U.K. meets its energy needs substantially from its indigenous resources of coal, oil and natural gas with the addition of small quantities of nuclear and hydro power. But we cannot opt out of world energy problems. And rising U.K. fuel prices in line with world trends and long-term marginal costs have emphasised the need for conservation. The role of energy efficiency will become even more important as indigenous production of oil and natural gas peak out in the 1990s and decline thereafter. The scope for conservation from the cost-effective application of technology is large - about 100 million tons of coal equivalent (tce) a year. This represents about a third of our current annual energy consumption of a little over 300 million tce and is equivalent in size to the coal, oil or gas industries. U.K. Government policy has, therefore, been to promote cost-effective conservation measures against a background of 'realistic' fuel prices by means of substantial programmes of information and advice to consumers, financial support for innovation, general financial support and regulatory measures.

2. The industrial and commercial sector is an important target area - it uses over half of our energy with about two-thirds of that for process and the remainder for heating buildings. Because of the traditionally low price of energy, it had not been thought necessary to invest to the same extent in increasing the efficiency

of energy use as opposed to other resources. The abrupt change in energy prices therefore revealed a need to 'catch up' on the application of technology and to increase its priority in relation to other calls on investment resources.

3. Conservation is not a negative concept - it is not a case of cutting back on energy usage for its own sake. Increased energy usage may be necessary to improve working conditions, increase mechanism and so forth. Basically, it is a question of realising a major potential for cost saving, improved productivity and higher profits. Processes which were acceptable when energy costs were small are no longer appropriate. For copper, energy has doubled its share of total manufacturing costs since 1970. It is one of the few elements of costs that is directly controllable, with an immediate and tangible effect on profitability.

4. This paper describes the U.K. government's energy conservation policies and how they have operated in the non-ferrous metals sector.

BARRIERS TO CONSERVATION

5. Obviously, economic pricing of energy is central to an effective conservation policy. Energy prices must reflect the workings of the market and so give energy consumers the correct signals for the future so that they can adjust their practices and investment decisions accordingly. However, although pricing has had a marked effect, much more remains to be done. Moreover, the nature of the response is somewhat disappointing. It is true that considerable progress has been made with good housekeeping measures. But a recent study found that whilst a high proportion of the firms covered had made energy savings by means of better use of existing plant and minor energy related alterations, less than a third had undertaken major energy-related investments.

6. This reluctance to undertake major new conservation projects is evidenced by the very short payback periods demanded for conservation investments; these often seem to be less than 18 months, even for large concerns. These short pay-back periods suggest both that individual firms may not be giving a high enough priority (in terms of their own interests) to energy conservation investment, and that at a national level the allocation of resources in the energy sector may not be optimal. One striking illustration is that the average age of the boilers replaced under the Energy Conservation Scheme was 41 years and of those projects involving conversion from oil or gas to coal, 15% of the boilers being replaced were Lancashire boilers aged between 70 and 80 years. Moreover, when the scheme started, the average payback was expected

to be 3.7 years but rising fuel prices have meant that the average (of 44 firms recently sampled) has reduced to 2 years. What are the barriers to profitable conservation projects like these?

7. Some of the main barriers which cause industry to neglect conservation opportunities are:

(a) A low priority for conservation, particularly at senior management levels. Decisions on energy use and conservation are not seen as major factors in firms' strategic objectives and are therefore accorded low priority in the allocation of resources, both managerial and financial.

(b) Uncertainty, both over the future level and pace of change of fuel prices and over the economic future generally. The problem is exacerbated at present by low liquidity, high interest rates, low profitability and low demand.

(c) A lack of appreciation of what can be achieved technically.

(d) Technical risks and uncertainties, particularly where new technology is involved (though in the vast majority of cases the technology is available). It is sometimes feared that conservation measures will not yield the predicted savings, or that they may cause more frequent disruption of production.

(e) The fragmented nature of the conservation equipment industry. Its products are dispersed throughout a wide variety of different industries and it is not geared to marketing conservation systems or energy efficient packages and providing follow-up services.

8. There is therefore an important role for Government in reinforcing the pricing messages. The U.K. Government programme includes a strong information programme, advice and training, and support for the introduction of innovative technology and for switching boilers and furnaces from oil and gas to the use of coal.

INDUSTRIAL CONSERVATION PROGRAMME

9. After the 1973 crisis, the Government realised that it did not have an adequate data base on energy usage in industry on which to base policy and strategy. Consequently, it initiated in 1975 a major and intensive Energy Audit of British Industry, designed to:

(a) obtain detailed information about energy uses;
(b) estimate potential savings;
(c) identify opportunities for RDGD:
(d) assist Government policy.

25 reports have now been produced.

10. During the audit work, however, it became clear that many companies were wasting a great deal of energy as a result of inadequate management and control of resources. There appeared to be a considerable scope, at very low cost, for better 'housekeeping' together with relatively simple modifications to plant and practice. In 1977, the Industrial Energy Thrift Scheme (IETS) was launched to:

(a) promote efficiency;
(b) obtain information on energy use;
(c) further obtain potential for saving.

In all, 40 reports have been produced.

11. As these schemes were proceeding, the Government introduced in 1977 a campaign for every organisation using energy - in industry, commerce, local authorities, hospitals, schools, government departments, etc - to appoint an energy manager solely responsible for the management of energy resources. There are now over 5,500 energy managers in the U.K. They are supported in a number of different ways. In each region there is a Regional Energy Conservation Officer, attached to the Department of Industry, who helps formation of local groups of managers from many different backgrounds (over 80 groups in the U.K.), backed up by a monthly free newspaper, training schemes and an annual conference, as well as a range of advisory material including Fuel Efficiency Booklets. It is also possible for companies to have subsidised advice on the energy efficiency of their undertakings.

12. At the same time the urgency of encouraging the adoption of innovative technology was recognised. Technology transfer has been one of the most intractable problems faced on a worldwide basis. It is particularly acute in the area of energy efficiency because none of the major parties involved - the researcher, the equipment manufacturer, the user and, in some cases, the fuel supplier - is well geared on its own to undertake the overall responsibility in this still developing field. Moreover, there are real risks associated with a new project - will it work in practice, will there by damaging interruptions to supply, is it really financially worthwhile? In times of recession, these factors are multiplied. The reluctance to invest is eloquently demonstrated by the fact that the take-up of existing and novel technology (which is believed to have the potential to reduce energy consumption in U.K. industry by 20-30%) has been painfully slow, even though most projects offered economic paybacks in less than 5 years and in many cases less than 2 years.

13. The Government therefore instituted a new scheme in 1978 to encourage the more widespread adoption of technologies that would increase the efficiency of energy usage - the Energy Conservation Demonstration Projects Scheme (ECDPS). This scheme is designed to:

(a) demonstrate the technical and economic effectiveness of technology in working situations by assisting the installation of equipment likely to lead to the improved use of energy and arranging for independent monitoring to verify the results of the systems;

and,

(b) encourage the replication of successful projects.

14. The scheme covers the industrial, commercial and domestic sectors, though initially emphasis was concentrated on industry where the shortest paybacks were obtainable.

15. A detailed strategy for the scheme as a whole and also for each individual market sector and each technology has been evolved, based on the results of the Energy Audit Thrift reports. Audit reports show for example that there are cost effective potential savings of 4-6 million tce per year in the iron and steel industry, representing 25% of its energy use, 0.2 million tce a year in the copper industry. The full list of Audit reports showing the conservation potential is illustrated in Table 1.

16. The same type of analysis enables priority technologies to be identified where the potential is great and there is a reasonable prospect of exploitation of that potential with high economic returns. In the industrial field priorities have been allocated, together with estimates of the cost effective conservation potential. Amongst the technologies for high priority attention are waste heat recovery where 6-8 million tce per year saving is available, waste material as a fuel (3-5 million tce per year), instrumentation and control (2-3 million tce per year) and cogeneration (1 million tce per year). A fuller list is illustrated in Table 2.

17. The latest initiative taken by the U.K. Government is promoting energy target setting and monitoring, which has been put into practice in the U.S.A., Canada and France with considerable success. It is clear from the results of the audit and thrift work that there is a wide variation in specific energy consumption between companies using similar plant and practices.

18. In order to minimise operational costs managers in companies need to know how and where energy is dissipated within their plants and to optimise the relationship between energy used and the production output or services rendered. However, energy targets set without any reference to the details of the way in which production is organized will be resisted and targetting and monitoring must therefore be tailored to the needs of individual companies.

19. Monitoring aims to reduce wastage and also optimise energy usage in existing plant operations. It incurs the following disciplined approach:

(a) measurement of energy flows within the plant;

(b) analysis and accountability of energy usage;

(c) normalisation of data allowing for effect of external factors;

(d) notification of performance to operational and top management levels.

Whilst follow-up action for performance drop-off invariably rests with the responsible line managers, monitoring also provides essential information for top management to ensure operating efficiency is effectively maintained.

20. Target setting is an additional activity directed to even greater energy conservation effort by all levels of management through their participation in a concerted endeavour to do better than normal. It involves:

(a) periodic auditing of energy flows and the identification of energy saving opportunities;

(b) the setting of goals for energy performance improvement allied to a realistic and agreed work programme;

(c) the execution of the energy conservation programme of work and the evaluation of cost benefits achieved;

(d) motivation of shop floor personnel.

Recent studies of industrial practices indicate that where companies have taken up disciplined energy accounting there has followed a greater impetus to undertake energy conservation projects. Target setting provides the requisite focus for the achievement of the maximum cost benefit from energy conservation endeavours.

21. The cost benefits achieved through Monitoring and Target Setting at plant level is compounded by support given at group and sectoral levels. The activity of an industrial sector co-ordinating body would include the following:

(a) a reporting procedure primarily to co-ordinate the overall efforts of the sector in the energy field but which will also help encourage the widespread adoption of monitoring and target setting systems in plants;

(b) a platform for the exchange of information between companies which provides for the improvement of energy management systems and also leads to an increased energy conservation activity.

ADMINISTRATION OF PROGRAMME

22. The implementation of these ambitious programmes could not be undertaken by Government alone. It was essential to work with industry and through the appropriate trade and research associations. The Audit and Thrift Studies have been sub-contracted to the sectoral associations or consultants. The Demonstration Scheme is managed by the Energy Technology Support Unit at the Atomic Energy Authority and the Building Research Establishment (some 50 staff in all. A sponsor is allocated to cover each market sector and each technological area. A key figure of the scheme is that these officers are responsible for all stages of activity from the initial audits of the sector, the specification of the strategy, identification of projects, management of projects, setting of targets for replication and the promotional programme to achieve replication. In addition to the sponsor's efforts, each project is 'vetted' for its suitability for Government support by a group of independent industrialists and experts.

APPLICATION OF PROGRAMMES TO THE NON-FERROUS SECTOR

23. The non-ferrous metals sector (excluding aluminium) includes copper, lead, zinc, titanium, ferro alloys, nickel and chromium alloys and semi-conductors. Although small in comparison to steel (which accounts for 20% of our industrial energy usage) its energy usage (2-3% of industrial use) is much the same as the aluminium sector (2.5%) and so is a significant individual target.

24. The following table shows 1981 U.K. production and consumption ('000 tonnes).

	Ingot		Wrought Metal Production	Castings Production	Employment	Ingot Price/Tonne
	Production	Consumption				
Copper	136	333	466	59	33,000	£900
Lead	333	266	150	-)		£350
Zinc	82	185	16	37)		£900
Tin	15	11	-	0)	17,000	£7,000
Nickel	25	24	-	-)		£3,000
Titanium		4	4	-)		£7,000

25. Primary metal production, manufacture of semi-finished products and castings and the recovery of metal from scrap accounts for 2.5% of industrial energy consumed in the U.K. and 1% of total energy consumption by final user. In 1974, the copper sector used 12,900 TJ of energy and the rest of the sector 14,000 TJ. Sales of copper amounted to £1,100 million, with an added value of £250 million, and of other metals to £1,200 million with an added value of £250 million. There are 430 establishments producing copper, brass and other copper alloys and 280 producing miscellaneous base metals.

26. BNF Metals Technology Centre has long been active in energy conservation in the metals industry and since 1975 has been responsible for implementing the Department of Industry's Audit and Industrial Energy Thrift Scheme in the U.K. non-ferrous sector. As a result of these and other related activities, the Centre has a unique knowledge and understanding of energy and its utilization within the non-ferrous sector. The Government has therefore invited it to undertake the independent monitoring of several major demonstration projects in this sector and the development of a sectoral monitoring and targetting scheme.

AUDIT PROGRAMME

27. It was decided to divide each metals sector into representative activities (eg. flat rolling of copper) and to assess the energy consumption per tonne of product passing through the various production stages in one or two representative works for each activity. The results were then scaled up in proportion to known production statistics, making allowances for factors such as the technological differences between companies. BNF audited approximately 40 individual sites with an average time, including the analysis of the data obtained, of around 10 man days per site.

I.E.T.S. PROGRAMME

28. This was based on a campaign of one-day confidential visits by teams of research association staff and independent consultants to representative companies in the industry - ie. to all U.K. industrial companies in a particular sector above a certain minimum size. BNF visited 84 sites in the copper, lead and zinc sectors. The essential element in the I.E.T.S. is the direct aid provided to companies during the visiting programme and from the subsequent reports. Each company visit is in reality a short consultancy performed by experts, each of whom has not only detailed knowledge of energy conservation but also experience of the industry concerned.

RESULTS

29. The results of the Audit and I.E.T.S. work now provide what is probably the world's most comprehensive centralised knowledge and understanding of how energy is used in industry, together with the potential for conservation. In addition to this, the industrial sector reports, which are widely available free of charge to U.K. companies, show the levels of energy consumption representative of each activity within the sector. This allows an individual company to compare its performance with the average, and if it is poor, action will be stimulated. It also gives scope for analysing company performance, eg. comparing the efficiency of energy consumption with labour productivity for several companies operating similar plant and processes.

30. These studies showed a high potential for increased energy efficiency in the copper industry and in lead and zinc.

COPPER INDUSTRY

31. In some respects, the copper industry is similar to the aluminium industry. However, energy consumption is much lower in the copper industry, because there is virtually no primary smelting of copper ore carried out in the U.K. (A small amount of primary copper is obtained in the U.K. from lead/zinc ore concentrates.) Almost all of our primary copper requirements are imported, amounting to some 271 kilotonnes of refined copper and 68 kilotonnes of unrefined copper in 1980. Furthermore, the intrinsic primary energy content of copper (50 GJ/tonne) is much lower than that of aluminium (250 GJ/tonne). The U.K. copper industry is therefore concerned only with the semi-fabrication of copper, together with the recovery of scrap copper, which supplied some 40% of the copper used in 1980. Energy use in 1980 is estimated to be 9.10^6 GJ (heat supplied), or 0.5% of the total U.K. industrial energy use.

32. The U.K. copper industry can be divided into four distinct sub-sectors:

(a) refining of copper scrap and imported unrefined primary metal (known as 'blister');

(b) semi-fabrication of pure copper;

(c) semi-fabrication of copper alloy (brasses and bronzes);

(d) conversion of scrap copper alloy to ingot and remelting to produce castings.

33. Secondary refining from scrap accounts for about 20% of the refined copper used in the U.K.; a further 12% or so of refined copper is obtained by refining imported 'blister' copper (impure copper obtained from roasting sulphide ores). Most of the refining done in the U.K. includes a final electrolytic process which produces the very high purity copper required for electrical conductors. The proportion of copper which is only fire-refined fell from 60% in 1969 to 13% in 1980. Semi-fabrication of pure copper accounted for approximately 88% of the refined copper consumed in the U.K. in 1980, most of which was used for production of copper wire (55%) and tube (20%). The continuous casting and rolling (CCR) of wire rod has in recent years largely replaced the traditional wire bar casting and rolling technique, with significant energy savings. The copper alloy industry is largely based on the recycling of copper alloy scrap. There are a large number of foundries which cast copper alloys directly to their final shape, using sand-moulds or shell-moulds.

34. The annual consumption of copper in making semi-fabricated copper and copper alloy products has fallen from a peak of 815,000 tonnes in 1965 by 44% to 460,000 tonnes in 1981. Part of this decline, particularly the sharp slump since 1979, is due to the general effects of recession. However, the long term trend is also downward, reflecting an increasing substitution of other materials (for example, aluminium, stainless steel and plastics) in the traditional applications for copper and the effects of miniaturisation and value analysis which has resulted in production of equivalent components containing less metals.

35. The energy conservation potential in this industry was estimated as 30% of the energy consumption in 1974, although subsequent studies suggests it could be getting on for nearly 50%. The detailed estimates based on the Audit Study are at Table 3 and the longer term potential on R.D. & D. is shown at Table 4.

36. Considerable progress has been made since 1974. This was largely due to better control of energy-consuming operations, either managerial and technical (better burners, recuperators, etc.). There has also been a shift away from low-grade scrap refining. Nevertheless, much of the energy saving potential identified in the Energy Audit remains to be fulfilled.

37. Since most of the energy used in the copper industry is used in furnaces for melting metal, reheating it for hot working and annealing it, it is to be expected that improvements in furnace design and operation represent the greatest scope for energy saving. There are various measures which can be taken, ranging from fitting existing furnaces with improved burners and more extensive instrumentation, to installing new furnaces of better design. (A more detailed analysis is at Table 5.)

38. Waste heat recovery from an anode furnace has already been installed in one copper refinery, with the recovered heat used to heat the electrolysis tanks. In other circumstances, waste heat could be used to preheat combustion air. However, waste heat recovery still presents technical difficulties, and the economics are somewhat marginal at present fuel prices.

39. Continuous casting has already penetrated most of the copper wire sub-sector; the extension of the technique to the casting of wide-strip and other shapes suitable for further working to make final products is beginning to occur.

40. These techniques contribute to energy saving for two reasons:

(a) reheating of castings for hot working is avoided;

(b) metal losses in trimmings, etc., which have to be recycled as clean scrap to the metling furnace are reduced.

The total energy savings potential of these measures amounts to some 30-40% of the 1980 energy requirement.

41. In the longer term, additional measures could further reduce the energy requirement. These measures involve the application of new technologies which are still in the development stage:

(a) high reduction milling;
(b) conform extrusion;
(c) seam-welded tube;
(d) powder metallurgy.

42. High reduction mills produce a much greater reduction in thickness of metal in a single pass than is possible in a conventional mill. This is achieved by an oscillating mechanism so that the incoming strip is rolled repeatedly as it passes through the machine. An energy saving of 4.7 GJ/tonne would result from the elimination of intermediate annealing between rolling operations. Further economic advantages result from the compactness of an installation.

43. The conform extrusion process can be applied to copper rods and sections; combined with continuous casting of the input rod, a potential energy saving of 30% is possible.

44. Semi-welded tube: Tube made from continuously cast strip which is folded into a circular cross-section and welded along the seam would reduce the amount of metal that is required by conventional tube-making processes, in which the central core of a billet is removed

and returned to the melting stage. The energy saving from this process might be about 10% of the present energy requirement for tube-making, although this has not yet been demonstrated. However, since the process would involve substantial investment in new equipment, and the product would need to gain acceptance over seamless tube, it is not likely to make a significant impact in the short term.

45. Powder Metallurgy: Many metal products can be produced directly by compacting powder into the final shape and fusing it with a heat treatment. An energy saving would result because of the elimination of the various intermediate process stages of melting, hot working and annealing. In principle, this could amount to 66% or more of the energy use in semi-fabrication, but the technique is still at an experimental stage, and it is too early to quantify the savings in detail.

LEAD AND ZINC

46. The lead and zinc industries can be divided into the following sub-sectors:

- (a) primary smelting of lead/zinc ores;
- (b) processing of zinc;
- (c) secondary smelting of lead;
- (d) refining and processing of lead.

47. There has been a downward trend in lead consumption since 1965. Secondary production has, however, risen by 250% over the same period. Total production of refined lead, including that refined from imported bullion, has been about 10% higher than domestic consumption since 1975 (statistics on total production prior to 1975 are not available). The U.K. is thus a net exporter of refined lead.

48. The decline in the consumption of lead has been due to the development of battery technology which increases the power:weight ratio. There has also been displacement by alternative materials, especially in plumbing and pigments, where concern over the toxicity of lead has been a marked influence. The use of lead as a petrol additive will decline, if not actually cease, for the same reason, while its use in the printing industry for type metal will be displaced by new printing technologies. However, lead will continue to be used for secondary batteries, in buildings (for flashings) and in chemical plant, where its corrosion resistance in aggressive environments is valuable.

49. The long term trend in zinc consumption shows a gradual increase, fluctuating with the business cycle and interrupted by sharp slumps in 1973 and 1979. Approximately one third of domestic consumption is met by primary smelting in the U.K., from imported ores. A small amount of domestic ore is also smelted (zinc content, 4 kt).

50. The most important uses of zinc are for galvanising steel, for alloying with copper to make brass and for die-castings. Die-castings are used extensively in the building and engineering industries. Zinc strip is used for dry-cell batteries, and the oxide is used as a pigment. Although there are substitutes for zinc in many of its applications (eg. aluminium for galvanised steel, stainless steel for brass, plastics for die-castings) there is no acute threat to the zinc industry.

51. Most of the energy used in the lead and zinc industries is in furnaces of various types. The energy saving opportunities are mainly in the improved control and operation of furnaces. Table 6 quantifies these savings for each of the main sub-sectors of the industry.

52. In primary smelting of lead/zinc ores, the main opportunities for energy saving are:

(a) combustion of low calorific value gases for power generation (about 30% of the gases produced are currently wasted);

(b) recovery of heat from water-cooled launders;

(c) heat recovery from the sintering plant.

53. The energy saving measures which could be applied to the furnaces used for melting and holding metal are characterised as:

(a) good housekeeping (using existing equipment with care);

(b) improved furnace control (better instrumentation, automatic controls, insulation);

(c) improved scheduling;

(d) waste heat recovery;

(e) better yield of product, reducing the reprocessing of scrap.

These measures could ultimately reduce the energy use in zinc processing by 60% and in lead processing by 45%.

ENERGY CONSERVATION DEMONSTRATION PROJECTS SCHEME

54. There are currently some 203 schemes under way, of which 10% are in the metals sector. For most of these, project profiles are available, describing the projects, expected energy savings, costs and payback periods. (A list is at Table 7.) Within the

metals sector improvements in energy efficiency can be achieved by:

(a) modifying a particular process through either retrofitting a new technology or upgrading old equipment;

or,

(b) changing the manufacturing process to a lower energy route.

Both of these improvement mechanisms are being demonstrated under the ECDP Scheme. Two particularly interesting schemes are:

(i) <u>Retrofitting of new coal-firing techniques to copper melting furnaces</u>

IMI Refiners Ltd (IMIR) has installed newly developed pulverised coal burners incorporating oxygen enrichment at their Walsall smelter. These burners have replaced oil burners and preliminary results indicate an energy saving of of 25% due to switching to coal. Although only minor energy savings were detected when using oxygen enrichment, campaign times were reduced by as much as 20%. To date the project has been highly successful from both an economic and an energy savings viewpoint. Increased particulate generation with coal utilisation is currently being examined, together with methods of dealing with it.

The cost of the project was £328,000 with savings of £425,000, a pay-back period of less than a year. The amount of energy saved was 3,600 tce a year, with a replication target of 100,000 tce a year.

(ii) <u>Two-wheel conforms development</u>

A new development is under way at Metal Box which will utilize their scrap aluminium to produce hollow sections of aluminium extrusions. This technique (which is transferable to other non-ferrous sectors) offers the possibility of significant reductions in material losses and energy use. Savings in this individual project are expected to be about 4,600 tce a year with a replication target of 50,000 tce a year.

TARGETTING AND MONITORING

55. On behalf of the Department of Energy, BNF is carrying out a pilot demonstration project on energy targetting and monitoring in the non-ferrous metals industries and also in the private steel sector.

The non-ferrous programme started in March of this year and the steps involved are:

(a) review records;
(b) assess practice;
(c) instal meters and establish recording system;
(d) audit site;
(e) report and recommend;
(f) agree targets and timescales;
(g) monitor attainment;
(h) define on-going energy management system;
(i) report;
(j) promote throughout industrial sector.

56. An essential element of this programme is that the target and the timescale for achievement of that target must be set by each company on the basis of recommendations made by the consultant concerned, rather than being imposed from outside. Working in this way, a commitment by company management is obtained. The initial phase which will last between 1½ and 2 years is confidently expected to result in savings of at least 10% in each of the companies taking part; the on-going energy management system should provide further annual savings resulting from the regular updating of targets and an increased emphasis on planned investment on energy saving technology. Subsequently, the results will be circulated to the industry through BNF and in collaboration with the trade association, the activities required for replication of the monitoring and targetting management system within the non-ferrous industry will be set in train.

CONCLUSION

57. Economic energy pricing policies are essential to give the right economic signals to industry. But there are major barriers to conservation, which impair the working of market forces. Supplementary policies are needed, particularly in energy intensive industries.

58. A comprehensive sectoral programme is needed for meaningful results to be obtained. The United Kingdom method of setting up an adequate data base on energy usage in industry through the Energy Audits and the Industrial Energy Thrift Schemes provides a firm foundation of policy and strategy which could be helpful to other countries without a full data base.

59. The potential for increased energy efficiency in this sector is high. Much of it stems from the application of good 'housekeeping

practices' and existing technology. But innovative technology has an important role to play. So, too, do sectoral schemes of monitoring energy use and setting sensible energy targets at plant level.

60. Progress can only be made by persuasion. It is essential for Government to work closely with the relevant trade and research associations and with industry to improve information and to encourage prudent energy management, investment in improving energy efficiency and innovation and its adoption throughout the sector.

Table 1

ENERGY AUDIT SCHEME
SECTOR REPORTS AND CONSERVATION POTENTIAL

	SECTOR	POTENTIAL Mtce/yr (%)
1.	IRON CASTINGS	0.6 (12%)
2.	BRICKS	0.45 (45%)
3.	DAIRY INDUSTRY	0.25 (25%)
4.	REFACTORIES	0.15 (15%)
5.	GLASS	0.5 (30%)
6.	ALUMINIUM	0.2
7.	POTTERIES	0.07 (50%)
8.	BREWING	0.3 (33%)
9.	COKEMAKING	0.4 (10%)
10.	LEAD & ZINC	0.1
11.	CEMENT	2.1 (40%)
12.	COPPER	0.2
13.	FERTILIZERS	2.6 (15%)
14.	PAPER & BOARD	1.0 (20%)
15.	MALTING	0.25 (80%)
16.	IRON & STEEL	4.6 (25%)
17.	PETROLEUM	3.0 (30%)
18.	PAINT FINISHING	0.8 (45%)
19	TEXTILES	0.9 (25%0
20.	ENGINEERING	

Table 2

ECDPS: PRIORITY AREAS AND CONSERVATION POTENTIAL

Priority	Technology	Conservation Potential
. . . . .	Waste Heat Recovery	6-8 Mtce/yr
. . . .	Waste as a Fuel	3-5 Mtce/yr
. . .	Improved Instrumentation and Control	2-3 Mtce/yr
. . .	Heat Pumps	1 Mtce/yr
. .	Process Insulation	1 Mtce/yr
. .	Improved Drying and Evaporation	1 Mtce/yr
.	Industrial CHP	1 Mtce/yr
	Improved Machinery Drives	3 Mtce/yr
	TOTAL	17-23 Mtc/yr

Table 3

Technically Proven Energy Saving Potentials in the Copper Industry

Process	Technology	Potential Energy Savings %	GJ/tonne	Cost effectiveness (payback years)	UK Prospects
Melting, reheating, annealing	Improved, operation and control of fossil-fuel furnaces	10-20	1-2	1-3	Good in medium term Now
Melting reheating annealing	Improved furnace design: - fossil-fuel - electric	10 5	1.0 0.1	3-5	Good Now
Melting reheating annealing	Waste heat recovery from furnaces	10-15	1-1.5	Uncertain	Technical difficulties longer term only
Foundry casting	Scheduling of furnaces to reduce holding of hot metal	20	0.5	1-2	Now
Semi-fab	Continuous casting processes	30	1.1	3	Now
General	Improved maintenance of process machinery	3	0.5	2	Now
	TOTAL	30-40	5.2-6.7		

Table 4

R&D Energy Saving Potential in the Copper Industry

Process	Technology	Potential Energy Savings %	Potential Energy Savings GJ	Cost effectiveness (payback years)	UK Prospects
Strip Rolling	High reduction mills	15	0.2	Uncertain	Long Term only
Extrusion	CONFORM process	30	0.4	<3	Good in medium term
Tube making	Seam-welded tube	10	0.2	Uncertain	Long term only
Semi-fab	Powder metallurgy	ca 66	6.0	Uncertain	Fair in medium term

Table 5

METHODS OF INCREASING EFFICIENCY IN FURNACE OPERATIONS

Rescheduling

In the operation of furnaces, materials are often held at a fixed temperature to marry the upstream and downstream activities within a production schedule, i.e. the holding operation is often used as a regulator for the production schedule. For example, in the diecasting industry, a firm might hold liquid metal at a fixed temperature for a period which depends on the availability of moulds, shifts, manpower, etc. This holding operation uses expensive energy for its operation. Charges are often held overnight or at weekends resulting in considerable energy dissipation. Conversely furnaces and ovens are emptied but kept at a high temperature ready for charging with fresh material on the first day of a working week. Significant quantities of heat can be expended bringing furnaces to temperature following a weekend closedown or an overnight stop in production. In the above examples, considerable quantities of energy could be saved by rescheduling the production to make optimum use of the heating facilities. It is ironic that the costly high energy step in any process is often used as a means of matching raw material input to final output.

Good Housekeeping

Housekeeping measures which can have a direct bearing on energy savings include organising the oven or furnace charge to obtain a balanced load, removing contamination or moisture from scrap or other non-clean charge material prior to charging; and properly maintaining both the charge feed and charge removal mechanisms at all times. Furnaces can be charged and discharged using either a fork lift truck or an overhead crane. Although, with the former, replacement on breakdown is relatively straightforward, a breakdown at an inappropriate time with the latter can represent significant energy losses. In a recent visit to a copper castings manufacturer a 25 tonne charge of molten copper was held for seven hours while parts for an overhead crane were replaced.

Furnace Casting

The vast majority of furnaces or ovens in use at present are constructed from thermal bricks inside a metal framework. In the more modern furnaces employing low thermal mass insulation, a metal box structure is used and because the insulation is often fibrous or granular, it is sandwiched between metal or brick partitions. Although such furnaces have the advantage of being stronger than the more traditional double-brick type oven or furnace they suffer from the disadvantage of being less easy to re-line or repair. The casing of an oven or furnace is highly susceptible to damage through knocks and bumps, often from the charging mechanism, (i.e. a forklift truck or overhead ladle). With a brick casing, repairs can be made quickly (although the frequency of these repairs may be fairly high), while with the metal casing the degree of damage should be significantly reduced, although repairs will take longer to complete.

Insulation

The use of high temperature insulation in industry is one of the major ways in which energy can be used more efficiently. High temperature thermal insulation in U.K. industry has been the subject of a recent major study for the Energy Technology Support Unit, ETSU, and conducted by the Engineering Sciences Division, both of which are at Harwell.

Heat Sources

The type of heat source used in an oven, furnace or kiln is dependent on the availability of fuel at a particular site. Of all the fuel types only coal has not made a major contribution to furnace, oven or kiln fueling. In recent years, electric furnaces have made an increasing impact. It is worthwhile listing the advantages and disadvantages of electric heating as there is an increasing penetration of this fuel type in furnace development. These advantages and disadvantages are listed below. One factor which is not shown yet can have an effect on a decision to 'go electric' is the prejudice/experience for one type of fuel.

Advantages	Disadvantages
Highly efficient to customer	High capital costs
High turn down ratios	Low heating rates for non-inductive heating
No waste heat problem	Tendency to form carborundum deposits in certain applications
Possibility for automatic control	
Clean and silent	

Waste Heat Recovery

A number of newer types of industrial gas burners are currently available. All new burner developments have been made to reduce the primary fuel usage per tonne of metal processed. With porous element burners, and flat flame burners this is achieved through high uniform flame intensities and rapid metal throughput. With gas-fired recuperative burners, the waste heat from furnaces and ovens can be fed back to be used within the burner thereby reducing fuel consumption for the same flame temperature. In both cases air/gas is employed as a fuel. In the recuperative burner, hot, clean air is fed from a heat exchanger in the waste gas stream linto the burner. Air temperatures as high as 400^{o}C can normally be tolerated by this burner type. With the self-recuperative burner, the hot waste gas is drawn through the burner and preheats the incoming air; this is then mixed in the nozzle of the burner with the gas and combustion takes place. The main disadvantage with self-recuperative burners is that particulates in the furnace atmosphere can induce fouling which affects thermal efficiences and ultimately burner lifetimes. Another disadvantage is that the extracton of a hot atmosphere at the burner often upsets the temperature distribution within a furnace or oven and so adversely affects heat-treatment or preheat operations. Despite these disadvantages, self-recuperative burners have been shown to be significantly more energy efficient than conventional recuperative burners. They also eliminate the requirement for an air-to-air heat exchanger and the hot gases are available directly at the point of combustion.

There is on the horizon another competitor for furnace and oven fueling in the form of coal. This energy source has been traditionally used in the steel industry for furnace heating but it has recently been given a boost by the extention of the government's grants for the conversion of boilers to coal firing to cover furnaces and ovens. It is probable that in the next 2-3 years coal firing will make a small but significant impact into the furnace, ovens and kilns market.

Furnace controls

Many furnace controls are manual or semi-manual and the heating conditions at a particular time are determined soley by the furnace operator. Understandably, operators are often motivated by throughput requirements rather than maximum energy efficiency, and poor furnace operations can result. For example, if rapid melting is attempted then the fuel rates to a burner can be increased producing excessive radiation, convective and conducive losses without a significant improvement in the heating rates. Incorrect settings of controls can result in charge being held at too high a temperature, excessive heat loss, and aslo shortened furnace lifetimes.

One of the obvious ways of rectifying the situation is to take immediate control away from the furnace or oven operator. With the advent of the microprocessor, a number of companies are now selling oven, reheat and heat-treatment furnace control systems which will allow furnace conditions to be automaticaly changed when the charge is added to or removed from the furnace. These devices can improve furnace lifetimes, save considerable amounts of energy and improve throughput. There is, unfortunately, still no commercially available microprocessor system to control melting and holding furnaces. A recent development by BNF Metals Technology Centre, BNFMTC, uses a microprocessor to control the operation of a copper melting furnace, and the British Aluminium Co. Ltd is currently investigating the control of an aluminium holding/casting furnace under an EEC R&D grant. The results from both projects look promising although figures are not yet available on the long term energy savings or reliability of the controls. The control of furnaces operating at high temperatures (greater than 800^{o}C) is hampered by the inadequate temperature measurement systems which are available in this temperature range. R&D is required in this area to develop a simple, cheap and robust device for measuring high temperatures in furnace atmospheres.

Input/output ports

With all furnaces, ovens and kilns there must be mechanisms for both introducing and removing the charge. With metal furnaces there is an additional requirement for an aperture to remove oxice or dross from metal surfaces during melting or holding. All of these apertures in a furnace can result in heat losses and it is therefore considered good housekeeping to ensure that doors are not only closed during non-essential periods but are aslo well insulated and fit well into the furnace. With many of the control systems available for heat treatment furnaces, burners are often automatically turned down when doors are opened.

Waste Gas Stream Exit

In non-electrically heated ovens, furnaces and kilns there is a requirement for an exit port to allow waste gases or hot air to escape. This exit represents one of the main areas of energy loss in the operation of the furnace.

Table 6

ENERGY CONSERVATION POTENTIAL IN THE LEAD AND ZINC INDUSTRIES

Process/Measure	Average PER (G/J Tonne)	Potential Energy Savings %	Potential Energy Savings GJ	Cost effectiveness (payback years)	UK Prospects
Primary Smelting	52				
- combustion of blast furnace gas		10	5.2	5	Likely to be installed by 1990
- heat recovery from sintering plant		10	5.2	10	c.a. 2000
- heat recovery from cooling water		10	5.2	10	c.a. 2000
Zinc Processing	23				
- good housekeeping		10	2.3	<1	
- improved furnace control		20	4.6	5	
- scheduling		5	1	5	
- waste heat recovery		20	4.6	10	
- product yield		5	1	5	
Secondary Lead Smelting	16				
- good housekeeping		10	1.6	<1	
- waste heat recovery		10	1.6	10	
Lead Refining and Processing	5				
- good housekeeping		10	0.5	<1	
- improved furnace control		20	1	10	
- waste heat recovery		10	0.5	15	not likely to be used
- product yield		5	0.3		

Table 7

PROFILE NO.	ABBREVIATED TITLE
18	Rotary Regenerative Air Pre-Heater on Aluminium Melting Furnaces
24	Self Recuperative Burners on a Heavy Forge Furnace
25	Recuperative Burners on a Continuous Reheating Furnace
28	Space Heating from a Bale-Out Furnace
38	Space Heating from Heat Treatment Furnace Burn-Offs
50	Design Study for Heat Recovery from Iron Foundry Cupolas
51	Reduction in Metal Melting Energy by Improvement of Yield of Good Castings in the Iron Casting Industry
53	Microprocessor-Controlled Waste Heat Recovery at a Copper Works
54	High Velocity Heavy Fuel Oil Burners for Alumimium Melting
63	Low Thermal Mass Muffle Furnace
92	Heat Recovery from an Aluminium Melting Furnace for Air Preheating and Stock Drying/Preheating
93	High Speed Continuous in-line Annealing of Copper Tubes
94	A Flux Degassing Unit for Treatment of Aluminium Alloys
95	Energy Reduction in the Production of Spheroidal Graphite Iron Castings
107	A Single Burner Tundish Dryer
115	High Efficiency Electric Radiant Holding Furnaces on Diecasting Machines
115	Bale-out Furnace with Low Thermal Mass Insulation
118	Pulverised Coal Burners Incorporating Oxygen Enrichment to Direct Melting Furnaces
120	A Recuperative Burner-Fired Plate Heat Treatment Furnace

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Project Profiles in the Metals Sector

RATIONAL USE OF ENERGY IN THE ALUMINUM INDUSTRY

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The subject of energy is of critical importance to every nation, industry, business and individual. In the past, the United States' economic strength has, in large measure, been based on a generous, diverse supply of low cost energy. However, the distortions in supply, and the increasing energy prices of the past decade, have stressed the American economy. Energy, although not the only factor, is a major reason why the U.S. has witnessed a slowdown in productivity. To remain competitively strong, industry in general, and the aluminum industry, in particular, must replace or retrofit plants which are obsolete in terms of energy consumption and technology.

When a significant proportion of the United States' aluminum smelters were built in the 1940's, 10 kilowatt hours (kWh)[1] of electricity were required to produce a pound of aluminum. Currently, about 8 kWh are required by Pacific Northwest Plants. However, new technology requires only 6 kWh. This change is significant when one considers the escalating price of electricity and the substantial amount of electrical power that the aluminum industry consumes (i.e., over 70 percent of the industry's energy consumption is in the form of electricity).

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1 Renner, W.B., Vice Chairman, ALCOA: The basis is a plant located in Vancouver, Washington, USA.

Fourth Annual Energy Conservation Technology Conference and Exhibition, Houston, Texas, April 1982.

The rapid increases in energy prices led to conservation, which in turn led to the end of predictability in energy demand forecasting. More troublesome and with potentially severe consequences to the utilities and their ability to make rational load forecasting decisions, is that the U.S. industry has matured to a point where its infrastructure needs rebuilding. An eroding baseload causes even more complications in forecasting power consumption and building capacity consistent with these forecasts.

The current recession has also exacerbated the situation. As a result of higher interest rates and falling aluminum demand by major consuming industries (e.g., automotive and housing), aluminum inventories soared, peaking at just under five months' consumption in the spring of 1982; inventory levels have generally averaged three months' consumption. Although steps were taken to reduce operating costs by producers, the quickness and level of response were not enough to counter the more rapidly deteriorating economy.[2]

Another potentially serious effect of the recession is the capital formation program of the aluminum industry. In a Chase Econometrics survey[2] of the five-year investment plan (i.e., planned increments to aluminum capacity during the 1981-1986 timeframe) for the major primary aluminum smelters, there appears to have been a substantial decrease in the planned incremental capacity. More specifically, a survey in December 1980 by Chase Econometrics indicated that, during this five-year period, 2.4 million metric tons of incremental capacity was being planned; the most recent survey, in December 1982, showed that this had been reduced

2 Adams, Robin. Journal of Metals, February 1983. "The Impact of the Recession on the Aluminum Industry and its Customers."

to only 1.3 million metric tons. This increment represents 9.1 percent of the current world capacity and an underlying rate of growth of less than two percent per annum. Given a rate of growth in U.S. consumption to be 3-4 percent compounded per annum, the current domestic investment plan is clearly insufficient relative to the prospective growth in domestic demand. On this basis, some industry analysts (e.g., Robin Adams), foresee a repeat of the situation occurring in the late 1970's, when the real price of aluminum doubled in a comparatively short period. When one considers the lead time required for new smelters, the likelihood of another violent cycle in the aluminum industry is great unless steps are taken to increase production flexibility and efficiency, and to avoid inventory and price swings.

Indeed, the recession has had a significant impact. However, the U.S. economy has begun to recover. With the reduced rate of inflation, an upward trend in real consumer income, a substantial "unspent" consumer spending potential on durables, and the reduction in interest rates, the expectation is high that markets for aluminum products will increase as part of a strong recovery in the metals industry and the U.S. economy in general.

As we are all aware, numerous forecasts have been developed with regard to aluminum demand and production. The U.S. Bureau of Mines in late 1982 forecasted a 5.5 percent annual rate of growth of demand through the year 2000. Kenneth Brondyke[3] suggests that, with an incremental increase of primary production of 1 million tons and an annual

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3 Brondyke, K.J. Journal of Metals, "The American Industry in 1982 and Outlook for the 80's," April 1983.

increase of primary production of 3.5 percent, U.S. primary aluminum capacity will not be exceeded until 1989.

Although there has been a diversity of opinion projecting primary aluminum production (e.g., on the pessimistic side, V. Besso[4], while M. Fitzgerald and G. Pollis are more optimistic[5]) one fact appears clear; secondary recovery of all forms of aluminum will represent an increasing fraction of the total aluminum supply throughout this decade. For example, aluminum production by secondary recovery methods in the U.S. has gone from 50 percent of primary production in 1978 to an estimated equal amount in 1982.[6] This increase, resulted, in part, from growth in beverage can recycling by primary aluminum producers who process large quantities of used cans as source metal for can sheet and, of course, from extensive shutdown of primary production during 1982.

Trade in bauxite, alumina and aluminum ingot is international in scope, as these basic raw materials have become international commodities. Bauxite is mined in 27 countries; alumina is produced in 26 countries; and primary aluminum is produced in more than 40 nations.

The U.S. aluminum industry, with extensive investments in ore and smelting operations in many parts of the world, continues to rely on foreign sources for bauxite. In 1982, less than 5 percent of the total supply came from domestic ore and a majority of the domestic alumina refineries are totally dependent upon imported bauxite. Although the

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4 Besso, V. J. Revue de L'Aluminum, "Aluminum in the Not-So-Gay 90's," November 1982.

5 Fitzgerald, M.D. and G. Pollio. Journal of Metals, "Aluminum The Next Twenty Years," December 1982.

6 Mineral Commodity Summaries 1983, U.S. Department of the Interior, Bureau of Mines.

U.S. has an abundance of non-bauxite alumina sources - clays, anorthosite, alunite, coal wastes and oil shale residues, the recovery technologies, which currently exist, have not proven more economical than the Bayer process. Research in these areas continues and I will explain in greater detail the activities supported by the Department of Energy later in this presentation.

One-third of the U.S. aluminum industry capacity is located in the American Northwest. The attraction, of course, was the abundance of low-cost hydroelectric power that grew from the federal government's establishment of the Bonneville Power Administration (BPA). In the 1930's the aluminum industry, as well as other industries, were lured to this part of the country to obtain the long-term, stable, low-cost power. In turn, industry provided the sorely needed baseload to justify develop--ing the area's huge hydropower potential. Indeed, the arrangement was beneficial to all.

However, electricity prices have risen sharply. For example, in the Northwest today's electricity bills are 750 percent higher than 3 years ago.* With the recession induced demand dropping, as well as other factors, the electrical utilities have faced new challenges in providing large blocks of power, on a continuous basis, at reasonable cost. Energy must be managed carefully by every industry; however, it is essential to the aluminum industry -- electricity being its lifeblood. The competitive advantage that the Northwest provided is rapidly disappearing. The long-term higher cost and uncertain availability of energy has prompted some shift in aluminum production to less developed nations. Countries like Australia and Brazil, which possess both bauxite and energy, are attracting aluminum production capacity.

*W. B. Renner: Please see previous citation.

In early May, the BPA took a bold step toward meeting this challenge. It has offered, for the duration of 1983, power to the aluminum industry at 11 rather than the current rate of 25 mills per kilowatt hour.

The application of sound energy management techniques and accurate comprehensive planning will play a critical role in determining where the aluminum industry will be located in the world.

Through the years, many technological improvements have been made in producing aluminum from bauxite. Further improvements in material handling equipment and increasing the energy efficiency in smelting are expected. Methods to use new inert materials for cathodes and anodes in the reduction process, computer control of the electrolytic process, reconfiguration of the electrodes and cells and improvements in the overall thermal efficiency of the cells have been and continue to be the objective of government and private research programs throughout the U.S. and the world.

A major source of inefficiency in the production of aluminum is the energy wasted in the bath resistance between the two electrodes. In typical smelters the bath drop accounts for as much as two-thirds of total energy losses. Narrowing the anode to cathode distance is a strategy to reduce the energy consumption rate. An inert or non-consumable anode is being investigated, which would permit a precise and better controlled setting, of perhaps two centimeters, from a titantium diboride cathode. The anode-cathode distance in conventional smelters must be maintained above about 4 centimeters to prevent intermittent shorting between the anode and the turbulent metal pool which serves as the cell cathode.

In addition, given the trend in petroleum coke prices and the energy conservation feature of saving one-half ton of coke per ton of aluminum, the prospects of the inert anode being developed are looked upon very favorably.

Over the past several years, the U.S. Department of Energy's Office of Industrial Programs (DOE/IP) has supported research in this field. Specifically, in 1980 the DOE funded the Aluminum Company of America to develop improved anodes. The first phase of the research has included selecting a design for an improved anode, as well a research and development on candidate materials. Two design options were originally considered: (1) development of a protective coating or sleeve for carbon anodes and (2) development of new inert anode materials to replace carbon.

Research has determined that the development of coatings for carbon is not an effective approach to improving anodes. Attention has therefore shifted to the development of inert anodes, composed of metal oxide ceramics, that would have an expected life of at least two years. Further materials research is planned, to be followed by anode fabrication and laboratory-scale testing programs. Additionally, a 20,000 ampere test cell will be designed during 1983. The new "cermet" anodes will be useful for retrofit applications or new cells.

The potential of titanium diboride as a fixed-cathode material was first realized by the industry in the 1950's and 1960's. Kaiser Aluminum pursued development of the concept as far as actual testing in 10,000 ampere cells, and demonstrated significant energy savings. However, the effort was terminated when it became apparent that the titanium diboride cathode components available at the time contained too much titanium carbide (up to 25%) and could not withstand the harsh environment in a Hall-Heroult cell.

The first titanium diboride cathode inserts developed by Kaiser used carbothermically produced powder, containing admixtures of up to 25% titanium carbide that was hot-pressed into final shape. Inserts made by this procedure exhibited poor impact strength and thermal shock resistance and also allowed severe intergranular penetration by the molten aluminum. As a result of this early development work, revised material specifications were developed as general criteria to maximize service life in the Hall cell environment. They were:

- o High purity (>99% titanium boride);
- o Absence of sintering aids that can react with molten aluminum or cryolite;
- o Low residual oxygen content (< 500 ppm);
- o High density (>97%); and
- o Fine uniform equiaxed grain structure.

Based on the above material criteria, Kaiser estimated it would be possible to develop a cathode material with a reliable service life of several years.

In light of the energy market of the 1970's and the ability to produce higher purity titanium diboride cathode components, Kaiser, sharing the cost with the U.S. DOE, resumed the development effort in 1976. A 15,000 ampere cell was retrofit with a fixed cathode made of two different types of titanium diboride insert, and operated successfully at anode-cathode distances of approximately 1.9 cm (i.e., 0.75 inches).

Once a reliable wettable cathode and inert anode pair is available, these joint developments could eventually result in a "bipolar" cell, a long-range goal of the industry.

The inert anode and titanium diboride cathode have been shown to be practicable, that is, under laboratory conditions the devices operate and have apparent advantages over present practices. Both Kaiser Aluminum and Alcoa appear to be improving on their original materials and methods, so that practicability is improving. However, research is needed to solve the corrosion and erosion problems. Also the consequences of combining the nonconsumable anode with the wettable cathode must be subjected to extensive research, development and testing.

Accordingly, the DOE has recently initiated a project to acquire in-depth knowledge of the candidate materials' behavior during electrolysis. Specifically, work which will be conducted by the Massachusetts Institute of Technology (MIT) will investigate, under electrolysis, cryolitic dissolution of cathode and anode candidate materials produced in single crystal form. Data from these experiments will provide a fundamental understanding of the dissolution mechanisms associated with the material itself, rather than those associated with fabrication or impurities.

Also, the proposed work would apply the latest technology in the fabrication of ceramic materials. A unique method of producing single crystals of powder via laser-activated pyrolysis of highly pure liquids has been developed. Recent literature indicates that highly dense, mono-sized grained materials are best produced by using these precursor materials.

In a related activity, research on the limits of current efficiency in Hall cells has been undertaken. More specifically, the proposed research will study the effects of multiple valence on the electrodeposition process in molten salts. Through the measurement of vibrational spectra of metal halide complexes in melts of commercial significance during electrolysis, the effects of so-called subhalides on the electrodeposition process will be determined. This will be accomplished by applying Raman spectroscopy, the technique acknowledged to be the most powerful means available for the study of ionic species. This is possible due to the fact that the Raman spectrum usually consists of fairly short lines which are little affected by admixture with other species. Furthermore, in systems where chemical or electrochemical reaction occurs, the presence of new species can be detected by the appearance of new Raman lines. The method does not disturb the chemical reaction and gives information about the electronic state of the species present. In addition, vibrational spectra will aid in the identification of "metal fog" which is observed in molten salt electrolysis cells during operation. And finally, the results will help to explain yet another mysterious occurrence during electrolysis: the coloration of the electrolyte, which is normally transparent. It is generally agreed that each of the above conditions reduces cell efficiency and results in higher energy consumption. Thus, a knowledge of the natures of the subhalides and "metal fog," and the causes of coloration, will both aid our understanding of this important class of melts and serve to guide subsequent improvements in the technology to make it more energy efficient.

"Red mud," the by-product from the extraction of bauxite, is a waste material (i.e., containing aluminates, enriched in iron and titanium oxides) requiring handling and large land areas for settling and disposal. Utilizing red mud offers the potential to recover the valuable metal feedstocks and reduce the volume of waste produced. Although red mud has not been successfully utilized as a byproduct, several research efforts have been conducted to develop methods to recover its valuable materials. Bioleaching, a process which enhances the solubilization of sulfide ores (i.e., through the direct and indirect metabolic action of microorganisms), has been applied to red mud in a few preliminary studies (e.g., Hungary). Although the available information shows a definite potential, the procedures and test results require validation. Accordingly, the DOE's Idaho National Engineering Laboratory has agreed to undertake a scoping study to verify and expand on the previous studies applying bioleaching to upgrade red mud. In this research activity, the effect of microbial action on red mud, and the effect of microbial action when red mud is supplemented with reduced iron and sulfur compounds which are required for cell growth, will be explored. Red mud is deficient in these components and enhanced leaching of silicates, sodium and aluminates could be accomplished with these additives. The removal of the components mentioned above will increase the iron oxide content of the remaining solids, making the product more suitable for iron smelting.

The leachates will be checked for titanium and vanadium content. Leaching this material will also make the "red mud" more suitable for further processing and the recovery of titanium and vanadium could be recovered as valuable byproducts. Secondly, the study will determine if bauxite can be upgraded with a microbial treatment. Thiobacillus strains and possibly Penicillium species will be innoculated on several different bauxite samples. Since no previous literature data is available on microbial bauxite leaching except for one abstract from Russia, the initial work will examine the influence of several parameters on the leaching of bauxites.

The policy of the U.S. government is to support high-risk, high-reward (i.e., energy savings) research of a fundamental nature. The national benefit of prime concern to the industrial energy conservation program is increased energy efficiency. However, the U.S. energy program should be viewed as a catalyst ultimately leading to full private sector involvement in advanced technology utilization. The primary component of that catalyst is a technology research and development (R&D) support program.

The inherent characteristics of energy conservation R&D (i.e., high risk, long duration, large capital expenditures), concomitant with industry's policies and investment practices, has to a great extent precluded pursuing of significant energy conservation process R&D solely in the private sector. More specifically, federal participation in energy conservation R&D has and will continue to evolve because:

- Industry acting alone is reluctant to pursue R&D which is non-exclusive. The private sector has little incentive to be the leader in R&D unless the benefits of the innovation can be protected.

- Industry alone will not perform R&D which responds more to the national welfare than to its own. A variety of relatively slow payback R&D activities fall into this category, and include alternative fuel utilization technology, industrial waste utilization, and materials recycling technology.
- Industry cannot easily perform R&D in direct cooperation among competitors. A promising, but very capital intensive, high-risk R&D concept may be beyond the capability of the originating firm, but collaboration with a second firm may violate antitrust laws.
- Industry alone will selectively avoid R&D with a long-term expected payback period. The corporate investment horizon even for R&D is extremely short when available funds are limited.
- Industry cannot perform R&D beyond the firms' or industry association's research capability. The historically low R&D levels in the energy-intensive process industries have resulted in limited research capabilities within these industries.

Thus, many important opportunities to reduce oil and other scarce fuel consumption in industry lie outside the primary thrust of private sector research.

The first oil price shock in 1973 caused U.S. industry to rapidly accelerate its efforts to reduce energy costs and enhance security of energy supplies by reducing energy consumption and switching to low-cost fuels wherever possible. This shift toward a greater emphasis on energy conservation in industry has not been a smooth one, but the overall direction has been clear.

Although some energy conservation efforts began immediately, it took several years for many companies to be convinced that higher energy prices were here to stay. It also took time for a new industrial energy conservation "infrastructure" to develop. Eventually, many firms established and staffed corporate-level energy management programs. By the time of the second large jump in oil prices in 1979-1980--and the continuing decontrol of domestic oil and gas prices--companies in most industrial sectors had their conservation programs well underway and were prepared to quickly respond to the added energy conservation incentives created by the 1979-1980 price increases.

As industry's energy conservation programs continued, there was a natural and logical evolution in both the type of energy conservation measures undertaken and the extent of their implementation in individual industry sectors. Early energy conservation programs and activities in all industrial sectors were concentrated on those measures which yielded the highest savings at the lowest cost--and with minimum disruption to existing operations. The implementation of a wide range of these low and moderate cost measures, championed by the newly created corporate energy managers, spread throughout the manufacturing sector. These housekeeping and moderate cost measures made particularly significant contributions to energy savings in those industries with medium-to-low energy use levels.

By 1981, however, it became increasingly clear that industry was moving toward the next stage of its energy conservation efforts. As individual companies and industries progressed in their search for energy savings, the number and type of energy conservation options available to them had also changed. A large portion of the cheap and simple projects had already been done. The achievement of further energy productivity gains would be increasingly difficult and complicated, and would come in large measure only from more expensive, capital-based projects.

The predicted trend toward more capital projects had other implications. Because most of the more energy-intensive sectors are capital-intensive sectors--and are also the sectors with the highest incentive for achieving further energy cost savings--a growing share of total industry energy savings would nave to come from those sectors. Second, there would probably be a widening divergence in the nature and scope of the energy conservation projects pursued by different industry sectors. As the relative cost of available energy savings increases, relatively low energy-using industries will find it harder to justify capital projects aimed solely at energy conservation. A third implication of the need for capital projects to achieve further conservation is a need to make energy efficiency a major consideration in the planning of all new capital projects and a reduction in the segregation of energy-saving projects from other types of investments.

The federal government has played a key role to ensure that energy efficiency improvements continue to be achieved, and has provided legislation that encourages fundamentally sound energy planning and research.

Recognizing the potential implications of an increasing and uncertain power supply in the Pacific Northwest, in December 1980, the Congress of the United States enacted Public Law 96-501. This law, the

"Pacific Northwest Electric Power Planning and Conservation Act," in conjunction with other applicable federal and local legislation, established a representative regional planning process to assure the region of an efficient, economical, reliable and adequate power supply. To accomplish this, the law provided, in part:

- Loans and grants to consumers for increased system efficiency and waste energy recovery by direct application;
- Technical and financial assistance (e.g., credits) to, and cooperation with customers and governmental authorities to encourage adoption of maximum cost-effective conservation measures;
- Funding for studies and demonstration projects to determine the cost-effectiveness of conservation measures; and
- Mechanisms to offer industry long-term firm power.

Thus, both legislation and a continuing public sector energy R&D program have been instrumental in initiating an effective energy conservation program.

As we all fully understand, electric power cost and its reliable availability is critical to the aluminum industry. As such, although research should result in major energy improvements in smelter operations and incentives such as billing credits provided by the Bonneville Power Administration as encouragement to remain, or expand operations in a particular location, the aluminum industry will continue to be attracted to sources of low cost power.

Based on the consumption figures reported in Exhibit 1,* demand for primary aluminum in the United States will increase from 13 billion to

* Charles River Assoc., Inc., "Primary Aluminum Production and Electricity Consumption in the TVA," Region; March 1983.

EXHIBIT 1

U.S. PRIMARY ALUMINUM DEMAND
(Million Pounds of Aluminum)

	1981	1985	1990	1995	2000
U.S. requirements for Al ingot	12,033	15,900	19,500	23,800	29,000
Ingot requirements met by recycling					
New scrap	2,338	2,600	3,100	3,800	4,600
Old scrap	1,772	2,400	3,300	4,000	4,900
U.S. requirements for primary Al ingot	7,923	10,900	13,100	16,000	19,500

SOURCE: 1981: Aluminum Association.

1985-2000 Charles River Associates Incorporated estimates.

approximately 19.5 billion pounds from the year 1990 to the year 2000. This increase of 6.4 billion pounds, or 3.2 million short tons, would require production from the equivalent of approximately 11 smelters, each producing 300,000 short tons of aluminum. During the 1990s, the introduction of titanium diboride cathodes and inert anodes into some of the existing potlines of aluminum smelters in the United States could produce an effective capacity expansion of as much as 10 percent of U.S. capacity, or the equivalent to two 300,000 short ton smelters.

While successful research and development to redesign and improve the energy efficiency of Hall cells will reduce the importance of power costs relative to other smelter costs, smelter location will continue to be heavily influenced by power costs.

The use of aluminum in automobiles where its reduced weight saves petroleum fuels is well understood. It is also well known that many nations have extensive uses for the metal in residential construction and consumer products.

The initial use of energy in smelting aluminum is always the major hurdle to the development of an aluminum industry. The aluminum producers of the world have been very skillful in developing fabrication equipment to convert primary aluminum from ingot to mill shapes and consumer and construction products.

Historically speaking, third world nations have always used hydro and bauxite resources to generate exchange credits. Insofar as the rational use of energy is a policy determinant, the fabrication of aluminum into useful consumer, construction and electrical products provides the greatest benefits per unit of energy consumed. Aluminum common alloy products do not require much additional energy once the metal in primary form is produced or acquired.

Application engineering has been purused almost feverishly by the major primary aluminum producers for decades in their desire to create new markets for their products. Most of this technology is so extensively developed that it is readily available to any nation which wishes to use the development of requisite resources in the industrialization process.

Those nations who do not possess excess hydro power or bauxite resources generate significant value added by manufacture of construction, consumer and electrical products from aluminum for their own use.

Many businessmen equipped with imagination and resourcefulness in finding and filling consumer needs where none existed before have literally created new industries in the United States and other developed nations. In many cases these aluminum consuming industries do not go beyond a given nation's border and require only aluminum or aluminum scrap as a basic raw material. Since energy for remelt is approximately 5 percent of the energy needed for primary smelting, a significant contribution to a nation's well being can be made without undue demands on energy resources.

In summary, the energy crisis is subsiding but it has had a profound and lasting impact on the aluminum industry in many parts of the world.

Higher costs of electric power have forced primary producers of aluminum to examine the most basic characteristic of electrolytic reduction in search of energy conservation. Forecasts of future power cost increases prevent relaxation in the search for energy efficiency. Nevertheless, there are practical limits on the efficiency improvements which can be expected. Thus, third world nations with major undeveloped hydro power potentials have the opportunity to market such power to cover aluminum demand, which will surely grow in the foreseeable future.

This places such nations in an enviable position to further develop aluminum using industries in their own domestic economies. The fundamental properties of the metal, i.e. light weight, high strength, electrical conductivity and resistance to corrosion can be depended upon to stimulate demand if the metal and the tools to work it are present.

RATIONALIZATION OF ENERGY CONSUMPTION IN MINERO PERU'S CAJAMARQUILLA ZINC REFINERY

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Introduction

The zinc refinery is located 29 kilometres North East of Lima at an altitude of 450 metres above sea level in the District of Lurigancho, Department of Lima.

The plant started up in March 1981, having been taken over by MINERO PERU from the contractor on August 10, after the plant's capacity and product quality had been thoroughly checked, according to contract. Since this last date, the Refinery has been operated exclusively by Minero PERU S.A. staff.

The plant processes a yearly total of 220,000 tons of 52% zinc concentrates which originate in the Central Sierra of Peru. As a result of processing, 100,000 tons of refined zinc are obtained per year along with the following sub-products: 160,000 tons of sulphuric acid, 330 tons of refined cadmium, 1,200 tons of copper residues and 12,000 tons of lead-silver residues.

1. Metallurgical Process

This process consists of the following three main stages:

- Roasting and Sulphuric Acid
  The zinc concentrates that arrive are roasted at 930°C in the presence of air but without external heat being supplied since the transformation of sulphides into oxides generates heat which is used for steam raising and, afterwards, for electricity generation and process heating.

The roasted products are:

Calcine: Mainly zinc oxide and the oxides of various other metals contained as ore impurities.

Gases: Mainly sulphur dioxide but also oxygen and nitrogen is purified, dried and then used in sulphuric acid manufacture. The residual gases are then released by a chimney whose discharge point reaches 690 metres above sea level.

Steam: Between 26 and 30 tons/hour of 40 atmosphere steam are produced for the generation of 2,200 kW in a turbine-alternator. The steam leaving the turbine has a pressure of 4 atm. and is used for process heating.

- Leaching and Purification

The leaching is carried out by applying 95^0 steam to the calcine, continuously and in several stages, with the object of disolving the largest possible amount of zinc.

During this process, lead and silver are separated from the zinc and iron is eliminated in the form of jarosite in a different residue.

The zinc sulphate solution is purified by adding zinc powder. The Cu, Cd, Ni, Co and other impurities are thereby eliminated.

- Electrodeposition and Smelting

The pure sulphate solution is used as the electrolyte. Upon the passage of electricity the zinc is deposited on the cathodes and sulphuric acid is recovered to be reused in the leaching process. The zinc sheets are then smelted in an electric furnace and cast in either of three commercial shapes, according to demand.

2. Energy System of the Zinc Refinery

The main energy forms used are:

a) electricity of hydro origin
b) electricity, steam generated
c) electricity, using diesel oil No.2 as fuel.

a) Hydro-Electricity

The plant's electric system is fed by ELECTROLIMA and has an installed capacity of 81 MVA, i.e. three monophase 27 MVCA and 220/30 kV transformers.

The distribution system is at 30 kV and is connected to four transformer-rectifiers of 12.5 MW power with the electrolysis system at a maximum of 446 V (DC) and 56,000 amp., where two units operate in parallel. Current is also fed at this voltage to an induction furnace with a power of 2.5 MW and also to two 12.5 MVA, 30/4.6 kV transformers. Current at 4.16 kV is then fed into 15 motors of different powers as well as into 4.16/0.44 kV transformers for feeding of smaller motors. The lighting system is at 220 V and controls at 110 V.

The maximum power made available by ELECTROLIMA is 60,000 kW and the monthly average consumption is 35,000,000 kWh, 15,000,000 kVARh with a power factor of 0.91.

The Refinery has the capacity to work with a stable load during the full 24 hours or varying according to peak power limits. Thus, the load factor is high at 0.89.

b) Steam-Generated Electricity

During normal roasting plant operation, the waste heat of the furnace gases is recovered in LAMONT WH boilers for the production of super-heated steam. These are watertubes with a nominal capacity of 30 ton/h steam at 40 bar pressure and 350^{o}C.

With this steam, electricity is generated in an ACEC turbogenerator with a power of 2170 KW and exit voltage of 4,160 V which is synchronized with the grid.

In addition, two emergency boilers of the following characteristics are available:

Directly Fired Boilers

Manufacturer	:	Menaeyer-Willebruck
Fuel	:	Diesel Oil No. 2
Type	:	Watertube
Fuel Control	:	Automatic
Capacity	:	33 Ton/h and 13 Ton/h
Pressure	:	10 bar, 10 bar
Flue Gases	:	250°C, 270°C

c) Diesel-Generated Electricity

During grid blackouts, the diesel engine and generator switches on automatically, the equipment has the following characteristics:

Manufacturer	:	Cockerill/ACEC
Power	:	3121 KVA
Power Factor	:	0.8
Fuel	:	Diesel Oil No. 2
Voltage	:	4,160 V

3. Specific Energy Consumption: 1982

Production of zinc bars	92,147 MT
Energy Consumption :	
Electricity	354,697.6 MWh
Diesel Oil No. 2	2,343.4 TEP
LPG (0.25 gal/MT fine Zn)	48.7 TEP
TOTAL FUEL	2,392.1 TEP

(1 TEP = 10^7 kcal)

Specific Consumption of Electricity

SEC_{el} = 3,849 kWh/MT fine zinc

Fuels

SEC_{th} = 260 kcal/kg fine zinc

4. Electricity Rationalization

During the plant's first year of operation the aim has been to take the best advantage of the established electricity tariff, the structure of which was 70% for active energy, 17% for reactive energy and 13% for maximum demand. Given these rates, the plant's consumption was programmed to be as uniform as possible during the full 24 hours. The reduction of reactive energy was planned and this is now underway.

In 1982 negotiations regarding a new tariff with ELECTROLIMA were started with the following results as of May that year. It was seen that Cajamarquilla's consumption could follow the load curve of ELECTROLIMA where the peak occurrs between 1800 and 2200 hrs. It was therefore proposed that the Refinery operate at 40,000 kW during this period and also eliminate the reactive energy by January 1, 1984 in exchange for no extra charges being made during peak hours, a proposal that was accepted by ELECTROLIMA. The Refinery thus took steps to maximise profitability by the best possible use of electricity supply.

The yearly established tariff ended on April 30, 1983 for which reason MINERO PERU has expressed its points of view to the pertinent authorities with regard to lowering power demand to 20,000 kW during peak hours, on condition that the lower revenue obtained would be compensated by at least a 10% reduction in the effective rate.

The application of the tariff just expired has meant a lower bill, with respect to the original tariff, of US$7 million per year in spite of the fact that the former was fixed in US$ and not in soles, as is the jcase for all other consumers.

Tariff System

Under the agreement with ELECTROLIMA, the new tariff is as follows:

a) Dry Period
Comprising the 7 months between May and November.

b) Wet Period
Comprising the 5 months running from December to April.

In each season, active energy is differentiated into two daily periods:

- Peak: Between 1800 and 2200 hours during which the Refinery may demand up to 40,000 kW by paying the highest tariff. Peak energy consumption is about 5,000,000 kWh/month.

- Base and Shoulder: Comprising the hours 2200 to 1800 during which the Refinery may demand the full 60,000 kW.

The peak tariff (active energy) is about double the base and shoulder rates.

Regarding reactive energy a transitional tariff was approved subject to the elimination of this energy during the current year. A low rate would be charged for reactive energy with a power factor of 0.98 and a much higher rate for lower factors.

Reactive energy will be eliminated by October of this year by the installation of a 25 MVAR bank of condensers and a synchronous 2 MVAR motor.

A study on the efficiency of the plant's electric system is underway which includes the operation of the motors at full load, using the transformers at maximum capacity and continuously checking the system's insulation.

Maximum demand is computed on the basis of peak load. The tariff is recalculated monthly according to the current US$/sol exchange rate. The average annual cost per kWh (including 25% tax) is 3.6 US¢.

5. Rationalization of Oil Consumption

The contractor that built the Refinery was also charged with start-up, delivering the Plant to MINERO PERU in fully operational conditions, where zinc recovery reaches 94%. However, for this, additional steam to that raised by the waste best boilers was required - some 6t/h - made possible by a 50% capacity use of the Willebruck boiler which entailed the use of some 60,000 gal/month.

Various tests were carried out with the view of saving oil and the conclusion was that the lower recovery of zinc by eliminating the additional steam would be less than 1% and this would lead to a bonus side-effect of reducing silica dissolution, always a problem in zinc recovery.

Hence, the following adjustments have been made:

a) Uniform operaton of the roasting plant by maintaining a minimum ratio of 2.3 between concentrates and zinc bars.

b) No use of extra steam, not even during roasting plant outage of less than 8 hours.

It has been found that the lower recovery of zinc in the leaching has affected total recovery by less than 0.5% or a monthly loss of US$13,000. However, the fuel savings are larger at US$48,000 per month.

RATIONAL ENERGY USE IN THE CEMENT INDUSTRY

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1. INTRODUCTION

The cement industry was an obvious choice for the list of topics to be presented at this meeting since it is definitely one of the largest consumers of energy in its various forms.

At every important event organized by local, national or regional cement guilds, or by agencies concerned with the generation and use of energy, economy in its use is practically a mandatory topic, and often the keynote. To mention but a few examples, this was the case at the first Colombian meeting on cement, held in Bogota in May 1976, and organized by the Colombian Institute of Cement Producers; at the second General Meeting of the Latin American Group of Cement Institutions; and in the paper on rational energy use and energy conservation in the Latin American cement industry, as presented in OLADE headquarters in Quito, in September 1981.

Practically every factory or company is working as well, at different managerial and technical levels, in the search for a reduction in energy consumption.

Although the origin and goals of governmental agency programs do not always agree with those of private enterprise, their endeavors on all fronts are making effective contributions to the universal problem of rational energy use and the conservation of energy reserves.

As must be expected, the orientation and intensity of these efforts differs from factory to factory, to a greater degree from country to country, and even more so, from region to region, as in the differences between Latin America and the countries of North America and Europe. These differences can be explained by greater or lesser motivations, the degree of development, general economic conditions,and their respective markets in particular; that is to say, by the availability and cost of energy sources and technological development and by the availability and competition on financial markets and the cement market itself.

2. FORMS OF ENERGY CONSUMPTION IN THE CEMENT INDUSTRY

The industrial process of cement manufacture may be broadly summarized as follows:

Mixed in determined proportions, calcium, silicon, aluminum, and iron oxides are fed into a revolving furnace, in which they go against the current of the gases produced by the combustion of coal, fuel oil, natural gas, or some other fuel. The heat from these gases decarbonates the calcium carbonate, which then breaks down into lime and CO_2, drives water from the clay that provides the aluminum oxide and silica, melts the iron oxides, and raises the temperatures to some 1,700°C, at which point the oxides combine with each other in various ways to produce clinker, the basic product leaving the furnace.

Depending upon the moisture content of the mixture of raw materials fed into the oven, the process can be dry, wet or intermediate (semi-dry or semi-moist). This variable is the determining factor in energy consumption, since the water must be removed by evaporation.

The thermal energy consumption of the furnace is highly variable, depending on the type of process used, as already explained; the quality and type of clinker produced; and the type and condition of the insulation; the condition of the furnace and its control; the quality and homogeneity of the fuel; and the adequate handling of the balances of mass and of energy, mainly. Consumption values can vary between some 700 and 1800 Kcal/kg of clinker.

The clinker produced in the furnace is mixed and ground very fine, normally in ball mills, together with gypsum. It is also common to add other components to the mixture, as in the case of pozzolanic materials, furnace slag and fly ash, which are considered as active additives, or limestone and other inert materials. As can be clearly deduced, the thermal energy consumption per ton of cement is inversely proportional to the amount of clinker present in this mixture.

In addition to the grinding of the clinker and other cement components, the process includes other size-reduction operations. The limestone, clay, iron ore, gypsum and sand are pulverized in the different types of triturators. The mixture of the raw materials and the carbon are ground in vertical roll mills or horizontal ball mills. All these machines consume large amounts of electricity, and their transformation into useful energy is quite inefficient. It is thought that the pulverization work yields a real efficiency of 2 to 20% in the pulverizing process (1). These pulverizing operations consume 80% of the electricity used to manufacture cement. This energy consumption depends on the type of machinery, its design, construction, and the condition of the equipment in terms of wear, the nature of the materials being worked with, and the balance between their initial and final sizes.

Given the size of cement plants and the variety of operations, it becomes necessary to transport materials over large distances, which may total several kilometers and many meters of vertical distance. This transport also consumes electricity, along with the above consumption and that of lighting, laboratories, and administration; the specific figure may vary from one factory to another from some 100 to 150 kWh/ton of cement produced, depending on the general condition of the facilities, the plant layout, the condition and efficiency of the machinery, the type of process and operations applied and, in general, a rational programming of the machines that will allow them to work at full load and avoid part loads. Finally, the energy cost depends on an adequate design of the system so as to allow efficient energy conversion in the variable-speed machines and the improvement of the power factor, among other aspects.

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(1) " Manual Technológico del Cemento " by Walter H. Duda, published by Editores Técnicos Asociados, S.A., Barcelona 1977.

The location of cement plants currently hinges upon the location of the limestone quarry, which supplies the main raw material. All the other minerals and fuels must be transported to that site, along with the machinery, parts and replacement parts, and personnel. And from that site, the finished product must be transported to the centers of consumption. All of this transportation, together with the movement of mining machinery and vehicles, requires considerable consumption of automotive fuel.

The Situation of Latin America

The existence of huge reserves of petroleum, natural gas and coal, as well as the great hydroelectric potential of most Latin American countries, on the one hand, and the high cost of technological innovations, on the other hand, make it necessary for these countries and their business to consider the question of rational energy use and energy conservation within a context and parameters that are different from those faced by the highly developed countries.

As in many other sectors of industry and economy, the cement industry has several international conglomerates which produce on almost every continent and the economic, technological, and productive scale of which is greater than that of the sum total of all the companies in many Latin American countries, where they are also implanted through subsidiaries or partnerships. These transnationals command a high degree of technology and quite a broad field of research and experimentation, the results of which they either pass along to their respective branches or offer for sale on the technological market, including the information regarding energy savings.

Technology in this field can also be transferred through the purchase of equipment, processes, or whole factories, normally at high prices, which are more difficult to afford under financial and cement market circumstances like the present-day ones: highly complex and uncertain.

Within this context, and corresponding to worldwide interest in the preservation and better use of energy resources, and as the above-mentioned diverse events and efforts express, the Latin American countries, their regional, state, sectorial and managerial agencies, are carrying out varying degrees of work aimed at this universal objective.

OLADE designed a ten-point program for Latin America at a Work Group meeting in Quito in 1981, including: energy balances; the analysis of legislation in this area; fiscal and financial incentive policies; mixed-cement production analyses; changes in processes; substitution of fuels; rationalization of equipment and processes; transport of raw materials and products; technology development, transfer, and diffusion; integration of efforts (2).

In this meeting, a partial diagnosis was made of the energy consumption situation in the cement industry, as compared with the situation in some industrialized countries. Although this was not the result of a well-prepared study, it did clearly show that, in general terms, Latin American consumption is higher than that of industrialized countries, and that the differences from one country to another are very large, as could be seen in the figures from the countries represented at that Work Group, i.e., Brazil, Colombia, Chile, Ecuador, and Venezuela.

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(2) "Program for Rational Energy Use and Energy Conservation in the Cement Industry in Latin America," OLADE Work Group GT/T/170-4/IX/81.

It was also interesting to note that the energy figures for the factories in the "HOLDERBANK" organization, located on practically every continent, are higher than the average for most Latin American countries.

In consideration of the importance of the exact diagnosis, the recommendation was made to prepare a survey of all the manufacturers in the region, as a preliminary step towards the already prepared ten-point program.

It is also known that government policies in this area are very different. In the area of handling of reserves, however, most countries have established very clearnorms and, in coordination with industry, quite concrete programs to find substitutes for fuel oil as an industrial fuel -in most cases coal or natural gas. And Brasil presented interesting examples of testing and application of the use of non-conventional fuels such as tires and by products of the chemical industry.

Perhaps one of the most clearly defined aspects has to do with the kind of process used preferentially by each country. It is evident and widely known that the dry process has a lower energy consumption than the wet process. The latter, relying on outdated technology prevails in Latin American countries. A change would contribute savings in energy consumption. However, such a change requires large investments that would greatly affect the particular features of national cement markets, because they always provide large additional installed production capacity, greater than the existing capacities. Therefore, in most Latin American countries, a solely private effort is unable to undertake such large-scale programs. Official backing is needed through credit programs, tax breaks, and other traditional measures.

With regard to the industrialized countries, possessors of high-level technology and improved means for the advancement of both basic and applied research, it is necessary to present the need for a better-defined policy on technological and financial collaboration and assistance, since every effort made by any country, or by the Latin American region, to economize on energy consumption is a very large contribution to augmenting worldwide reserves.

The Situation in Colombia

In the case of Colombia, at the national level, the "Energy Research in the Cement Industry", done within the national energy study that the National Planning Department carried out with cooperation from a German-Swiss technical mission in 1981, is quite important. The report by expert Mr. Peter Kalas (3) presents a series of figures regarding the size of the industry, its production, and its energy consumption.

The 41 furnaces installed in 15 plants could produce approximately 4 million tons of clinker per year, which could be turned into 5 million tons of cement; 31.5% of the nation's energy consumption pertains to industrial use, within which the cement sector demands 18.7% of the fuels and 9.8% of the electricity, "which means that the cement-producing sector is responsible for almost 6% of the energy consumption in Colombia".

Furthermore, the report concludes that the specific energy consumption is approximately 35% higher than the average consumption the world over (6.7 MJ/Kg. versus 4.95 MJ/Kg. of cement). This situation tends to improve with the inauguration of the new plants of Paz del Río and Samper Cement, whose specific consumptions meet international standards.

Regarding the type of fuels consumed, an important change can be seen with fuel oil consumption, in terms of cement production, reduced from 33% in 1970 to 10% in 1976, by replacing it with coal. In this aspect, the effort and contribution of cement companies is significant. Most of them have exploration programs, with concessions granted by the government; and in some cases, they do their own mining. For example, Cementos del Caribe (Caribbean Cement) organized a company devoted to the different phases of the economic exploitation of coal and has planned exportation of coal; and Samper Cement has gone even further by completing

(3) National Energy Study "Investigaciones Energéticas en la Industria del Cemento," National Planning Department. Bogota, August 1981.

the cycle with a coal-washing plant having a capacity of 120 ton/hr., with which a cleaner, more ash-free coal can be supplied, to make the furnaces work more stably and with less thermal strain. Besides the contribution to environmental control, this project can produce significant savings in automotive fuel consumption, both in the cement sector and in other industries.

Within the energy substitution program, fuel oil consumption has tended to be confined to just one plant, located far from the coal- or gas-producing areas, and to auxiliary consumption in different factories (preheating processes when firing up the furnaces, emergency electric generators, and others). As for natural gas, it will be substituted for coal insofar as factors such as plant location, or difficulty in its use for other applications, may permit.

This substitution process has been encouraged by the lower price of coal in comparison with that of fuel oil, $52/G Joule versus $480/G Joule, which represents a price nine times lower. This situation greatly compensates for the effort of the cement companies, as the investment is considerable, and the difficulties of technological adaptation are of such a magnitude that they have considerably affected the participation of many firms on the market. This substitution has only one negative aspect from the energy standpoint, which is the greater consumption of automotive fuel in the transport of coal; however, the resulting cost is much less than the savings in the industrial process in any case.

The study's recommendations stress the efficient energy savings provided by the utilization of the dry process instead of the wet process and, therefore, the need to encourage the establishment of future plants with this technology. The study also refers to the need to lend tax and credit stimuli to any energy-saving technological effort, for these always call for sizeable investments. Finally, the study recommends that the use of coal as a fuel for furnaces be continued.

It is important to mention the words of Mr. Kalas in the closing sentences of the report's introduction, in which he underlines the high degree of interest and the qualified collaboration that he received in the development of his work from government agencies, from the Institute of Cement Producers, and from the industrialists themselves, which reflects a lively interest in the topic.

In general terms, the thermal energy consumption of the Colombian cement industry is high. The consumption of electricity is relatively low. The Institute of Cement Producers has even reported that the energy consumption in 1981 was 104 kWh/ton produced, though it must be clarified that 10% of the production was made up of clinker that was not ground to cement.

The above-mentioned report by National Planning presents the following figures for the energy balance in Colombia.

Participation in the total energy consumption of each of the basic phases in cement production:

a. Preparation of raw material	3.8%
b. Production of clinker	93.4%
c. Production of cement	2.8%

Regarding the form of energy used, the participation is:

a. Thermal energy (process fuel)	92.0%
b. Electricity	7.0%
c. Automotive fuel	1.0%

Although it is amply demonstrated that the highest figures correspond to the process of baking in the furnace, in the form of thermal energy, the potential for energy conservation is also interesting in all stages and forms of use.

The private efforts in the different firms, to reduce energy consumption, are of different types. As in every region of the world, in Latin America, and in Colombia in particular, cement producers orient their actions in this field according to sound "business" strategy and in terms of daily production.

Examples of Energy Rationalization

Thinking in terms of the two basic goals of rationalization in energy use, i.e., preservation of reserves and decrease in specific consumption, allows me to analyze the different possibilities and measures applied or still applicable, using the case of Samper Cement as a model.

The company began to produce at the turn of the century. In downtown Bogota, limestone was processed in a vertical furnace. The limestone was taken there from the municipality of La Calera, Bogota's neighbor to the east, which is today connected with the capital by a 20-kilometer highway, built by the company at the end of the forties.

In the twenties, the first expansion was undertaken comprising the installation of a horizontal revolving furnace, grinders, and other equipment in La Calera, and a hydroelectric plant at the site called Sueva, some 30 kms northeast of the factory. Cement has been transported ever since along an airborne cable to the city of Bogota; it had initially been used to carry limestone. The recession of the twenties caught the company in the middle of important work on the furnace, turbines and trans formers.

New enlargements were made in 1948 and 1967; and in 1953, a new quarry was first exploited, located 15 kms. east of the factory, and connected by a 26-km. road that served as the entrance to the Chingaza project, the most important project for the Bogota Aqueduct of this century. The limestone from this quarry is transported along an airborne cable 15 kms. long, which takes advantage of the topography of the land (it descends from 3,600 meters above sea level to 2,700), making its electricity consumption approximately 0,75 kWh/ton of limestone carried. Applied to the 26 kms. of road, this is the equivalent of approximately 30 watts per ton per kilometer. The automotive fuel consumption for the same circuit is approximately 0.017 gallons per ton per kilometer. Thus, the total savings for one year is approximately 250,000 gallons of fuel.

For the transportation of most of the cement by cable to Bogota, where the topography of the terrain is not so favorable, the corresponding figures are 1.40 kWh/ton of cement, 56 watts/ton; 0.014 gal/km-ton, and approximately 125,000 gallons of fuel savings yearly. This cable also transports coal and other materials from Bogota to the factory. With the opening of new highways, the economy of this compensatory transport by cable is not so important as in the past but the savings may total on the order of 25,000 gallons per year.

Unfortunately, the high costs of investment and maintenance, as opposed to the present possibility of opening better, shorter, and better-designed highways, and using more efficient vehicles, have made it economically less attractive for Colombian industry to install this means of transport.

This has been the case in the recent spurt of expansion for Samper Cement, begun in April 1982. This project, costing over US$ 100 million, for a capacity of 500,000 tons of clinker per year, is located in the same township of La Calera, 8 kilometers southeast of the original plant and connected to Bogota by 38 kms. of highway, of which 15 are the old road to Bogota; 15 the old access road, improved by the company; and 8, new accesses built by the firm. The high cost of the project can largely be attributed to the costs of, and delays in, the work on the infrastructure, requiring a long, thorny negotiation process for the purchase of both the quarry and plant sites and the enlargement and road-building zones.

From the energy perpsective, this expansion displays the following characteristics with relation to its rational use:

- Introduction of the dry process, with two-stage preheating, which represents approximately 750 Kcal/kg of clinker in fuel savings, as compared with the old plant, which worked by the wet process.

- Installation of a clinkerization furnace at the end of the quarry, with a grinding and dispatching plant at an intermediate point, 21 kms. from the furnace and 17 kms. from Bogota. With this location, the total kilometer-tons moved per ton of cement produced is approximately 158. If the entire project had been established next to the quarry, this figure would have been 173. And if both the furnace and the grinder had been located at the midpoint, the figure would be approximately 180. The theoretical reductions in fuel consumption by this arrangement are on the order of 75,000 and 110,000 gallons/year for the installed capacity.

- Installation of a roll crusher to grind the raw materials before baking, which represents a theoretical energy consumption 20 to 30% lower than that necessary for the same work with a ball mill (4).

Installation of insulating refractory brick along 79 meters of the area of transition from the furnace, which represents an energy savings that could be as high as 13 Kcal/kg of clinker, represented by heat not radiated away into the atmosphere from the outer surface of the revolving furnace, according to general theoretical estimations (4) (5). This figure has not yet been confirmed.

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(4) "Possible Energy Savings in the Cement Industry" by Richard J. Grzelack C.E. Raymond. Aplicaciones Técnicas Industriales, S.A. - Revista Cemento Hormigón.

(5) "Fuel Savings Potential in Revolving Furnaces in the Cement Industry by Means of the Use of Refractory Insulation," by Alfonso Uribe Melguizo, Representative of GR-Stein Refractories, Limited. - Boletín Instituto Colombiano de Productores de Cemento (ICPC) No. 39-40.

- Installation of efficient electrostatic filters to retain and recycle dust from the furnace. Although this effect does not have as much impact in the dry process as in the wet process, since most of the dust in the dry procedure is recycled with the raw materials, the efficiency of the filter, aside from reducing air pollution, produces a savings in fuel consumption. One of the articles footnoted below, (6) affirms that "10% of the total dust loss would cost 100 Kcal/kg in fuel consumption."

- Outfitting of the plants with modern, automatic process-monitoring systems and instruments permitting optimization of the handling of the different variables that affect energy (both heat and electricity) consumption. This characteristic is also very important for the development and control of future measures taken to decrease energy consumption.

- Advantages offered by the vertical roll crusher, as well as the adequate design of all the motor systems and the monitoring of their work, will make it possible to attain a specific consumption of some 106 kWh per ton of cement, in camparison with the 135 kWh consumed in the old plant.

The general balance presented is similar for the Paz del Río cement plant, inaugurated at the close of 1981, where the dry process is used, with four-stage preheating, and capacity of 500,000 tons/year. The planned Río Claro factory will also be similar, producing 600,000 tons/year for the Colombian market by about 1986. This will mean a total of 1,700,000 tons/year more by that time, requiring approximately 200,000 tons/year of coal. In terms of electric power, these 3 projects will allow a reduction in consumption on the order of 51 million kWh/year.

The plants that use the wet process are also working with a large variety of measures to reduce energy consumption: decreases in the water

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(6) "Energy Savings Potential in Cement Operations" by P. Davis, J.A. Stringer. Blue Circle Group; ICPC. First Colombian Meetings on Cement.

content of the paste entering the furnace; improvements in the design of the production line, to optimize the heat exchange between combustion gases and the raw paste and to decrease the amount of dust issued into the atmosphere; use of additives for grinding; improvements in all the grinding and clinkerization facilities; and installation of adequate monitoring systems and instruments.

6. ADDITIVES FOR CEMENT

One of the most hotly-debated and controversial means of decreasing energy consumption in the cement industry is through the use of additives, meaning principally materials obtained from Nature and added to the cement during grinding, along with the clinker and gypsum.

The theoretical calculations for the Samper Cement plant make it possible to estimate savings as 1 kWh/ton and 17,000 Kcal/ton for each 1% of additives.

This topic was addressed in all its aspects, with extraordinary completeness, by professor Jose Calleja, Deputy Director of the IETCC in Madrid, at the Second General Meeting of the Latin American Group of Cement and Concrete Institutions (7).

The production of gray cement in Colombia has always been based on the manufacture of a clinker that is very good, normally surpassing the specifications for the clinker required for the manufacture of Portland cement type I, intended as multi-purpose cement and sold indistinctly for applications with the most varied technical requirements. Thus, no differentiation is made among the times required for the stripping of forms, or the variation in strengths depending on the time, especially when dealing with those applications where these two aspects are not fundamental, as in paving or plastering of interior and exterior walls.

(7) " Considerations on Economy of Fuel and of Other Petroleum Derivatives in the Manufacture and Use of Cements ", Prof. Dr. Jose Calleja.

The introduction of additives retards the development of resistance and prolongs the time delay before stripping off the forms. This variation means a greater proportion of cement in the concrete mixture, or a longer time in the development of the different tasks. This last variable, time, said professor Calleja, would be a reasonable price to pay for savings in energy.

Before the inauguration of the new Samper and Paz del Río plants, between 1977 and 1981, the Colombian market was a seller's market. This situation encouraged the search for additives for cement. In different regions of the country pozzolanic materials were found.

These constitute active additives, which contribute to the development of resistance in cement, once activated as a consequence of the hydration of the cement's clinker. Some very important testing was also carried out with blast furnace slag, which are also active additives, and earlier-acting than the pozzolanic materials. These experiments are important for the immediate future of the cement and construction industry.

The addition of high percentages (25-30%) of pozzolanic materials produces, in effect, pozzolanic cements for specific applications, such as those that require special chemical resistance. The construction of the Paz del Río plant originated because of the existence of a great quantity of slag in the steelworks, which would permit future conversion of this by-product into an important product, thereby using industrial energy consumption that would otherwise be totally wasted. Similarly, fly ash, a by-product of various industries, including electricity generation by heat engines, could be used, to allow for more complete utilization of coal.

Although it is very difficult to know exactly to what extent additives are being applied in the different factories, it may be assumed that over two million tons of additional cement have reached the Colombian market in the last few years in this way, which could have represented an energy savings of some 30 million kWh and some 80,000 tons of 6000 Kcal/kg coal.

When the market changed in 1982, due to the increase in the cement supply from newly-operating plants, most factories reduced their additives, in the search for a more competitive level with regard to the development of strengths and form-stripping time. The portion of the market that will not really benefit from these cement features, approximately 30%, will consume an additional amount of energy unnecessarily.

This situation shows the need, amply justified from the energy standpoint, for attempting to diversify cements according to their fields of application. Testing by Samper Cement and other factories has taken this tack, working towards the production of type II Portland cements with high initial resistance. However, slow-resistance-development products must clearly be promoted on the market for specific applications.

The way to attain this objective is preferentially through the control of the percentages of additives. Based on chemical variations in clinker and its components (8), which allow lower working furnace temperatures and the consumption of less energy, the other way is difficult to implement, due to its cost and technological requirements, for a market the size of Colombia's. Most Latin American countries have the same situation.

7. THE NEED FOR INCENTIVES

As in coal mining, in which the cement industry is somewhat self-sufficient, several cement companies have their own hydroelectric or thermoelectric generating plants. The electricity balance for the cement sector in 1981 is as follows (9):

Bought	:	399,338 MWh
Generated	:	124,973 MWh
Sold	:	41,370 MWh
Consumed	:	428,941 MWh

(8) " Investigations on energy-saving cements". P.K. Metha. World Cement Technology, May 1980

(9) Data Furnished by the Colombian Institute of Cement Producers

RATIONAL USE OF ENERGY IN THE CEMENT INDUSTRY

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SECTION 1 - THE AUSTRALIAN CEMENT SCENE

1. Australia may seem a remote part of the world to most of the delegates at this conference, and it may come as a surprise to learn something of its size. If a map of Europe were superimposed on the map of Australia it would be found that from east to west, the map of Australia would encompass the distance from Ankara in Turkey to Lisbon in Portugal, and from north to south, it would reach further than from Oslo to Athens! And yet within that vast continent dwell only about 14 000 000 people - both Shanghai and Tokyo/Yokohama have nearly that population in a city!

The reason for this small population is found in the character of the continent. In the centre are vast areas of hot and almost uninhabited desert, and the main population is located round the fertile edge of the continent, over half of it being concentrated in about six major cities.

Consequent on this, the sixteen cement making plants are also largely located round the edge of the continent and as close to the major cities as the availability of raw materials will allow. The major centres of population are 800 km or more apart, and so the supply of cement in each area is largely restricted to the local factories, with the notable exception of my own Company which operates its own specialised bulk cement ship and transports cement into its own two terminals located in the cities of Melbourne and Sydney from its plant on the southern island of Tasmania.

Due to this need to supply a number of discrete and localised markets, the development of the cement industry has been patchy. In some areas, notably Western Australia, the industry boomed a few years ago with a mining boom, and now that this has slowed down, Western Australia has excess cement capacity.

The present economic climate in Australia is, like most of the world, very depressed, and consequently the Australian cement industry with a capacity of about 8 000 000 tonnes per year has about 30% of idle capacity at present.

In a well developed country the cement consumption can be expected to be about 350 to 450 kg per person per year, and so the industry is reasonably well equipped to meet the demand when the recession ends, although some of the plant is old and of the wet process type which is expensive to operate, and some of the plant capacity may be in the wrong geographic location to supply a rising market.

Australian is a country rich in mineral resources - iron ore, bauxite, coal, copper, zinc, gold, silver, lead, uranium, tungsten and many others, and rich in primary industries - cattle, sheep, wheat, etc. I can feel confident that in the coming revival of the world economy our country has a very bright future, and with the growth of commercial activity the cement industry will certainly grow, and grow economically because of our large reserves of indigenous fuel.

Our plant commissioned major extensions two years ago, and a new plant opened in Queensland last year. My Company has further expansion plans drawn up, and we will proceed with these when the economic climate improves.

2. In Australia cement is made from a great variety of materials, ranging from coral and calcareous sands dredged from the sea, hard limestones that must be drilled and blasted, through to limestones soft enough to break out with rippers, and scrapers.

Raw materials are quarried on the plant site in several cases, but in others they are transported to the plants by ship, aerial ropeway, road, rail, overland belt, and even in one plant by wet raw milling at the quarry site and transporting the slurry over 15 km through a pipeline, to be filtered and fed to a suspension preheater.

There is even more diversity in plant types, ranging from the old type of wet process, semi-wet, (Lepol type), dry (suspension preheater type), vertical kiln, and precalcining suspension preheater. Fuels used are mainly natural gas and coal.

3. Let me now address myself to the changing pattern of fuel use in the cement industry in Australia. When I first entered the industry 30 years ago the norm was a wet process kiln or kilns, fired with coal. The only exception to this was one small dry process simple kiln which used waste heat for power generation and one small vertical kiln operation. Coal was the universal fuel, and about one third of the plants owned and operated small coal mines near to their cement making sites.

In the early 1960's Australia was importing increasing quantities of Middle East crude oil and refining it, and there was an embarrassing glut of heavy residual oil. Consequently the oil companies made very attractive offers to industries which could use such fuel, and many of the cement companies including my own, changed from coal to heavy oil fuel. The exceptions, as you might expect, were those who owned and operated their own coal mines. In fact, these plants have continued to use coal and are still doing so.

In the middle of 1960's the modern fuel efficient kilns began to appear in Australia. First a small suspension preheater, then a Lepol grate kiln, then two plants built larger suspension preheater kilns (ours in 1966), and progressively over the intervening years kilns of this type have been installed, until now nearly half the productive capacity in Australia is of the dry process type.

The next stage of the fuel story occurred progressively in the later 1960's and early 1970's when large fields of natural gas were found in Australia. Unfortunately, being a large country, the gas fields were all in remote areas, involving long pipelines to get the gas to the cities, and so certain industries, including some cement plants, were offered very attractive gas prices to provide a basic market to make costly pipe lines viable. Several cement plants accepted gas as their fuel and are still using it. My Company was not able to get gas supplies in our area, and our fuel remained oil. Then in about 1973-74 the escalation of oil prices began, and we made the decision to go back to coal fuel. We built a coal plant in 1975 and commissioned it in 1976 in time to avoid most of the impact of oil price escalation.

Subsequently we have converted the plant into a precalcining plant with the addition of a second preheater and in 1979 we purchased a coal mine to assure our fuel supplies.

4. The trend to energy efficiency in the cement industry is now world wide. The industry consumes large quantities of energy both as primary fuel and as electrical energy. Energy efficiency was being considered by the more progressive companies in the 1950's and 1960's when many new installations of the energy efficient preheater kilns were being made, but installations of wet process kilns (using 1.5 to 2 times as much fuel per tonne of product) were still being commissioned. The energy crisis of the middle 1970's changed the situation dramatically and the installation of wet process kilns practically ceased, and gave way to various types of fuel efficient dry process plants.

Other areas of energy saving have been pursued with less spectacular but useful results, such as more efficient electric motors, and improved electrostatic precipitators, which also save energy by reclaiming partly processed materials which would have been lost as dust. Larger kilns have been built as these are more efficient both in minimising radiation losses and incidentally in saving manpower, and most recently precalcining kilns have been introduced which contribute to efficiency in various ways, which I will discuss later in this paper. Perhaps the least successful area in energy efficiency is in milling of raw materials and finished cement. Certainly the vertical roller mill uses less energy than a ball mill but tends to have a high maintenance cost, and is unsuitable for some abrasive raw materials. Tandem mills which consist of a hammer mill in series with a ball mill have distinct energy advantages, which will also be mentioned later in this paper.

SECTION 2 - A CASE STUDY IN FUEL CONVERSION AND UPGRADING OF A CEMENT PLANT

I would now like to enter into a case study of the progressive upgrading of my Company's plant which has, I think, been an excellent example of progressive plant development in both energy and efficiency.

As I mentioned earlier, we originally had two small wet process kilns fired with coal, and subsequently with oil. These were phased out over 10 years ago, and eventually dismantled.

I will discuss the upgrading of our plant in three stages, describing each stage of upgrading and its consequences separately to show how they affected our plant at that time.

Some advantages which appeared at the coal conversion, for example, are less important now after two subsequent upgradings.

Part 1: Conversion from Oil to Coal Firing

I will describe our coal installation in some detail. Australia has vast deposits of coal of varying grades, ranging from excellent black coals of very low ash content, to poorer grades of 25-30% ash, and also very large deposits of brown coal (lignite). Our small island of Tasmania has considerable coal deposits of a medium grade (20 to 25% ash).

Tasmanian coal is a black coal which occurs in fairly shallow seams making working something of a problem. It is a non caking humic coal with about 23 to 24% volatiles and 45 to 55% fixed carbon and about 20 to 25% ash. It contains about ½% of sulphur and has nett calorific value of about 24 000 joules/gram (or 5 700 calories/gram).

The main problem from a technical point of view in conversion to coal burning was that the Humboldt kiln with the Claudius Peters batch homogenising system is not amenable to changes in coal quality, because there is quite a large amount (usually 1 to 1½ days supply) of kiln feed material prepared and stored in silos in such a way that its analysis cannot be adjusted. This is unlike our old wet process, where we could change the material fed into the kiln fairly readily.

This means that the first essential of a suitable supply of fuel is consistency.

As we had bought coal many years ago from a number of companies, and suffered with considerable variations in quality, mainly due to extraneous matter appearing in the coal, we approached the one remaining coal company in Tasmania, with a proposition that we would be potential customers for sizable quantities of coal (something like 50 to 60 thousand tonnes a year initially and possibly more at a later date) if they could guarantee us a supply consistent in ash content. This they were able to do, since they have a coal washery on their lease and they have access to several different mines. By blending coal from different mines with washed coal they undertook to give us an ash content of 23% ± 1% controlling their quality with a small laboratory at the washery.

The coal is shipped 150 km from the mine once a day, five days a week, in aluminium wagons designed by the local railways department which are very efficient coal carrying wagons, with an excellent pay load to tare ratio, being 50 tonne capacity wagons with only about a 13 tonne tare. These arrive at our Works in the evening, where they bottom dump into a pit. A vibrator feeds the coal on to a belt, over a weigher, and through an automatic sampler which is controlled by the weigher, so without any manpower of ours, the coal is unloaded and stockpiled in a double stockpile around two steel rill towers which gives us the capacity to store a large amount of coal. About 5 000 tonnes is our normal live storage, which is two to three weeks supply, but we can easily store up to 14 000 tonnes. Even more can be stored by bulldozing out and reclaiming later.

The coal plant that we chose for preparing the coal is a Fuller plant based on a Loesche vertical roller mill (LM 14) using hot air from the Claudius Peters cooler for drying. The coal is stockpiled in the open because it has the characteristic of not absorbing excessive moisture. At about 12 to 13% moisture it is saturated, and the amount of waste heat we have available to us will easily cope with this quantity of water in the coal.

The coal is extracted from the stockpile via an underground reclaim belt with a number of points of entry which is linked automatically to a one hundred and fifty tonne raw coal storage bin. This bin has a nuclear level device in it, and when the level gets down to a set point, the reclaim belt is actuated and the bin is automatically filled to a preset level. Coal is extracted from this bin with a vibrator, on to a belt weigher which is controllable by the kiln operator, and passes through a triple gate feeder into the hot air swept Loesche mill, which is capable of grinding coal up to approximately 14 tonnes an hour of wet coal.

The coal mill is swept by a hot air supply which comes from a triple air device connected to the grate cooler. Most of the drying air comes from the stack of the grate cooler which normally runs at about 220 to 230°C and provides sufficient hot air to do most of the drying, but to supplement this we have introduced a duct into the side of the cooler over the second chamber from which we can take air at around about 500°C through a de-dusting cyclone and use this to increase the temperature of drying air if needed. At the same time, there is a third air inlet which supplies cold ambient air to reduce the temperature of the air sweep. The blending of these three supplies of air is entirely automatic and is governed by the exit tempeature of the Loesche mill. A controller is set to keep this temperature at 80°C and it does this as the coal quantity and moisture content varies, by varying the ratio of the three sources of air. The inlet temperature of the mill must not exceed 400°C.

The coal having been ground, dried and swept out of the Loesche mill, passes up to a cyclone which drops it into a small pulverised fuel bin of about 15 tonnes capacity which is mounted on load cells. The air then sweeps on out of the de-dusting cyclone still carrying a small amount of very fine coal, and passes to a junction point where the primary air for firing the kiln is extracted from this warm air supply (approximately 70°C) and the excess air passes out through a five chamber bag filter system which shakes in rotation and a mechanism transports the collected coal back into the fine coal bin by induced suction.

The coal stored in the fine coal bin is at about 12% residue on 4900 mesh DIN, (or 170 mesh ASTM) and contains about 1% moisture. It is extracted through a rotary valve on to a weigher feeder on which the required amount of coal can be set, and fed automatically. Of course there is a small addition of coal carried through with the primary air and allowance must be made for this, but it is a very consistent amount to be added on to the amount put in by the coal feeder.

The coal passes off the weigher, through another rotary valve, and into the primary air stream. The primary air is about 10% of the total air used for combustion.

We looked at various methods of control of the coal milling system and contemplated a fairly sophisticated sort of an automatic control, but we have found in actual fact that is is extremely simple to control. The kiln runs very steadily. The amount of coal required is consistent and the whole system is operated by the kiln operator. He simply watches the level of pulverised fuel in his bin, keeps it a little over half full, and adjusts the feed to the Loesche mill within certain limits to either slowly raise or slowly lower the level of coal in the pulverised fuel bin. He would probably only have to vary the raw coal feed once or twice a shift.

There are a number of advantages of burning coal in our plant most of which we anticipated, but some proved to be more advantageous than we expected. (I stress that I am describing the situation when we converted to coal - the further alterations to the plant are mentioned later in this paper.)

The first and most obvious one is that it is a local product and is not subject to the vagaries of international supply. We have it available right within our State. It serves to increase employment in our State, gives employment to our railways department, it gives us a much more assured supply of fuel, and we are able to store very much more than we could oil fuel.

In our process, ever since it was installed, the raw mill had been a bottleneck. Our kiln was installed as a guaranteed 900 tonne a day kiln, and the raw mill was quite capable of supplying the amount of meal needed for this. However we very quickly found that the kiln was capable of producing more than its guarantee, and a great deal of work went into improving the capacity of the raw mill. However, we also increased the capacity of the kiln by making certain alterations to it, and over the years the limiting factor of our production had been the amount that we could force through the raw mill.

Fuelling the kiln with coal of 23% ash produced a number of advantages in our process. Starting from the quarry, we need less siliceous material. Our raw materials are hard blue limestone and a fairly wet clay which can be up to 30% moisture in winter. Since we are adding siliceous material to our mix by virtue of coal ash, we need to handle very much less clay through our quarry processing system, which is a double rotor hammer mill. Getting the clay material through this unit mixed with limestone had always been a problem and caused blockages and a great deal of wear and maintenance because of the abrasive nature of its siliceous material. Hence there is a distinct advantage in quarrying and crushing.

In raw milling we had always had a problem in the winter with reduced production due to the very wet, sticky nature of the clay material that we fed as part of our raw material. Milling for coal burning uses less clay as a raw material because of the siliceous ash addition in the kiln. Thus we found a very great advantage in that our raw mill ran with much less clay, and looking back at our production records for various years, I would estimate that over a full year, through milling less clay, we probably gained about 3 tonnes an hour of output from the mill because of its much better operation. With the mill bottleneck, this is equivalent to being able to make 2 tonnes an hour of extra clinker.

As well as this, we were burning sufficient coal to add 2 tonnes an hour of siliceous coal ash into the kiln, which of course, does not have to be raw milled at all. Consequently another 2 tonnes an hour of extra production came from the kiln, remembering again that the raw mill was the bottleneck. So altogether we can say that by burning coal our particular plant produced about 4 tonnes an hour of extra clinker. This equals about 32 000 tonnes of extra clinker per year, which, at that time, represented a 10% increase in production.

Thus we received value for our investment twice over - once through burning a cheaper fuel and once through effectively increasing the output of the plant by about 10%.

As a side benefit, we were putting considerably less sulphur into the kiln than we were when we burnt fuel oil and we found that the tendency for accretions to build up in the bottom of our preheater system was greatly reduced. They were not eliminated, but were greatly reduced compared to the quantities that we had on oil burning. So much so in fact, that we were able to operate the preheater with one man on day shift engaged in cleaning activities and he was not fully committed to the preheater and could do other things. However, with oil burning, for many years we had run with a preheater attendant on shift work. In other words, we were employing four preheater attendants to cover the four shifts. So we had quite a distinct saving here and this also has the effect of increasing the kiln capacity, because the limitation usually is on the amount of gas that you can pull through the system and the accretions in the preheater inhibit the gas flow.

Another benefit which became evident was a significant improvement in brick life. We think doubling of brick life was likely, but later improvements were made and we could never be sure which improvement was responsible. There is not doubt, however, that brick life with coal as a fuel was significantly improved in our plant.

We anticipated that in burning a lower sulphur fuel we would need to use more gypsum in our cement, and in costing for the conversion we allowed for an increase in gypsum, but we were pleasantly surprised to find that the SO_3 of our clinker was much the same as it was when burning oil. Obviously the extra sulphur from our fuel oil that was going into the system was being lost, and after conversion we would appear to be trapping virtually all of our sulphur, giving us a clinker with much the same SO_3 as we had before. We had anticipated a sizable increase in gypsum usage at a considerable cost, but we have found that this is not so, and that our gypsum usage was much the same as before, so this is another benefit above our expectations.

The conversion of our Humboldt plant to coal was a very satisfactory exercise both technically, because we were able to keep exactly the same standards of quality control that we had always insisted on, due to the good performance of our coal supplier in giving us a consistent fuel, and financially in that we enjoyed a cheaper fuel price than we would have had if we had continued burning oil and at the same time were able to produce more clinker with the same plant.

The coal installation is a very neat and simple arrangement. The milling and burning system was engineered by Fuller, and it is operated without any expenditure of man power. There is certainly a little more maintenance on it than there was on the oil preparation plant, (possibly one extra man, including cleaning) but from the point of view of operating man power the number of men we have on shift is reduced.

Part 2: Raw Material Mill Upgrading

In 1977, following the conversion to coal, our plant was running nearly to capacity, and the bottleneck in the system was the raw material ball mill, especially in the winter months, when a very wet and cohesive clay must be handled. Consequently it was decided to upgrade the raw milling section by adding a Humboldt hammer mill in series with the ball mill to make a "tandem mill". The normal Humboldt tandem mill integrates the hammer mill with the discharge end of the ball mill, and utilizes a single classifier and pair of cyclone separators. Owing to limitations of space, and to our inability to have an extended plant stop, we had to install the hammer mill as a separate unit, with its own classifier and cyclone separator. The raw feed enters the hammer mill and is swept out to the classifier. About 25% is fine enough to us used as finished raw meal, and the other 75%, which is of an even size and quite dry, having been rejected by the classifier, passes over a weigher and feeds the ball mill, which runs very steadily on such an ideal feed. Hence the whole milling plant was upgraded by about 30%, but the increase in consumed horsepower was only about 20%.

Part 3: Kiln Upgrading

Now the kiln was a bottleneck, so in 1979, in close consultation with Klockner Humboldt Deutz of Cologne, West Germany, the third upgrading was commenced. A decision was taken to install a second preheater, and a Humboldt Pyroclon precalcining system, to be wholly operated on coal fuel. At this time, we believe, no precalcining plant in the world was using coal as its total fuel.

In a period of 12 months a second preheater was built over the end of the operating kiln, together with a new electrostatic precipitator and associated equipment, two conditioning towers and a tertiary air duct. The twin preheaters have a common Pyroclon duct that rises up to the level of the No. 2 cyclones and curves back down to separate into two ducts serving the two preheaters. With a stop of about 6 weeks the final connections were made to the existing plant, and the cooler was modified from a 3 to a 4 chamber unit with the addition of an extra cooling fan.

The whole of this new installation was commissioned in August 1980.

The original preheater supplies all the hot gas for raw milling, and the gas from the new preheater is not used at present. However, the next planned stage of the plant development will see another raw mill in the new preheater gas stream, and auxiliary cooler, and a further upgrading of output. The current output of the kiln is 2250 tonnes per day, and with the proposed extra milling capacity it is expected to achieve 3000 tonnes per day.

Apart from the greatly increased output, major benefits are extreme smoothness of operation and a complete absence of rings building up in the kiln, which were previously a continual problem.

Hence, over the years the plant has been upgraded by 250%, and the eventual output is expected to be 330% of its original guaranteed capacity.

The upgrading has been achieved at a very modest cost, and when the final stage is completed the extra capacity will have been achieved at less than half the cost per annual tonne of an equivalent new plant. This precalcining plant is the only one of its type in Australia.

SECTION 3 - SOME POINTS IN THE CONVERSION TO COAL FUEL

I would like to comment on the actual conversion of a plant from oil to coal. Many cement plant operators may be concerned about problems they see in handling coal, but I would say that with a well designed and engineered plant, installed by people experienced in the technology, the problems are minimal. It is essential that gas flows and the coal to air ratios in the system be correctly designed, because at certain ratios coal and air can form an explosive mixture. The plant must have suitable explosion vents and fire protection.

Two basic types of plant are available, those in which coal is milled and fired directly into the kiln, and those in which coal is milled to a powder, stored, and then fired to the kiln. Both have advantages, but with the modern high efficiency kiln, the latter is the usual type.

SECTION 4: DISCUSSION OF RATIONAL FUEL USAGE IN THE CEMENT INDUSTRY

I have described these successive upgradings to lead up to a discussion of the way I see that the cement industry should move worldwide to maximise the rational use of energy.

Some plants in the world are still using oil, and some are using gas, but the price of oil and the rising price of gas is gradually making these fuels less attractive.

Conversion from one fuel to another is normally forced on an industry by economics. We converted originally from coal to oil because heavy black oil was very cheap, and we converted back to coal 10 years later because heavy oil was becoming so expensive. If we were still burning oil at the present price, our fuel cost would be at least 3 times as great as now.

But there are other good reasons for burning coal in a cement kiln. Oil and gas, despite shortages and gluts, are much scarcer resources in the world than coal. It is essential that these fuels be conserved for mobile equipment and for the petro-chemical industry and other areas where coal is not a substitute. Furthermore, high grade coals should not be used in a cement kiln if possible, as they are much more useful for power stations, etc. in that there is relatively little coal ash for disposal.

The great virtue of a cement kiln is that it can consume high ash coals with no ash disposal problems which are often an embarrassment in other applications, since all the ash is blended with the appropriately proportioned raw materials, sintered in the kiln, and becomes that very useful material, Portland cement.

As an example, one kiln that I know operating in Australia uses coal with 30% ash, so that of every 100 tonnes of cement it makes over 4 tonnes derives from coal ash.

Modern precalcining systems are particularly interesting because of their ability to consume poorer fuels. In these systems fuel is burned in two places. In the rotary kiln part, fuel is burned in the traditional way to produce a high temperature flame, and for this a fairly good grade is essential, although, I stress that even for this purpose a high ash coal is quite usable.

Approximately half the fuel, however, is burned in a special chamber in the preheater. Here, the reaction is not really a flame producing reaction, but simply a release of energy at about 900^{o}C which decomposes the limestone to lime. Hence a much poorer grade of fuel is suitable, and with the Humboldt Pyroclon precalciner which we use, a variety of cheap fuels or even waste products can be burned. In our case we use the same powdered coal as we do in the kiln, having modified our coal grinding system to give two weigher outlets. But some plants using this system in Germany have used unground lump coal, and even discarded motor tyres dropped whole into the Pyroclon duct as a source of fuel. It seems likely that most combustible waste materials if available in suitable quantities could be used in such a system, as long as their non combustible constituents are not detrimental to cement quality.

Discussion of government policy is not in my field of expertise, but I must stress the importance of encouragement being given to the cement industry to use poorer grade coals and other low grade fuels and to convert their operations to dry process, preferably with precalcining, to make the best use of such fuels. Something like 900 million tonnes of cement is made in the world annually, and making some assumptions of the mix of types of plant (older wet process fuel inefficient plants, and modern dry process efficient plants) the amount of fuel oil needed if they all burnt oil would be about 110 000 000 tonnes, or if they all burned 23% ash coal, about 200 000 000 tonnes. If all plants in the world were of the modern fuel efficient dry process type I estimate one quarter to one third of this fuel could be saved.

Therefore it would seem to me that it is most advantageous for both the cement industry and the government of any country to use indigenous fuel of types that are not suitable for most other purposes when they are available, (and such fuels are widely spread throughout the world). Local employment is stimulated, and money is kept in the country and not spent on unnecessary fuel imports. This may be done by decree, by artificially elevating the price of high grade fuels, or, more acceptably, by government assistance to open up marginal mines and to subsidise transport to stimulate the country's economy.

The question of the problems of developing countries merits special attention. In developing a fuel efficient cement industry, attention must be given to the problems of providing employment, of avoiding the outflow of money by importing fuel, and of not introducing too complex a technology too quickly. Most of my paper has concentrated on efficiency in fuel and manpower, but in a developing country I would see the ideal cement plant as one that is modern in its design and concept but simple to operate; one not locked into high technology where the infrastructure for highly specialised maintenance is not accessible; one that is able to use indigenous but lower grade fuels; one that is somewhat labour intensive, but leads itself to the elimination of some labour cost areas as the economy of the country develops. Coal mining, loading, and unloading, and bulk cement handling are all carried on in our organisation in a highly mechanised manner. I would see that a developing country should have coal mining done with much hand labour, and coal loaded and unloaded by manual methods also. The kiln would be a simple four stage preheater kiln as ours was originally, but designed to burn low grade local coal. Cement would be shipped mainly in bags.

However, the whole system would be planned so that mining, loading and unloading could be mechanised when needed. The kiln would be designed for upgrading, automation and possibly computer control when the economy and development of the country justified it.

I understand that some countries have already actively discouraged the use of gas in the cement industry by price increases or decree. This may not be a popular move with the gas users, but for the ultimate fuel resources of the world it seems to me to be a necessary approach, although I would personally prefer to see encouragement and help to use other fuels as a much better philosophy than coercion.

SECTION 5 - SUGGESTED INDUSTRY AND GOVERNMENT ACTIONS

What key actions should governments and the cement industry take to achieve the rational use of energy?

Industry must acquaint government with its unique ability to use local lower grade fuel, and ask the government through its mining development authority to identify and assess fuel resources.

Industry must be prepared to install the appropriate equipment and to adopt its processes to them, and to retrain its staff and employees.

A factual cost benefit study must be prepared.

Governments must react to industry's initiatives, and be prepared to encourage the use of local resources. Industry's cost benefit study must be supplemented by a government study of the benefits accruing to the country by the stimulation of employment and the saving of foreign exchange.

It may well be that, as a result of these investigations, even if the industry's study shows the conversion not to be cost effective, it could pay the government to help the industry to convert to local coal by subsidy, or the payment of a bonus on each tonne of cement made with local fuel, or by some form of tax relief, to the overall benefit of the country.

SECTION 6 - CONCLUSION

Financially the conversion to coal can be a rewarding exercise, and if approached with expert advice, should present no serious problem to any cement plant operator. The cement industry is in a unique position to contribute to the rational use of the world's energy resources through its ability efficiently to use poor grade fuels which are not suitable for most other industries, and, taking the long term view of the world's resources, cement manufacturers should be encouraged by their governments to convert their operations to such fuels wherever possible, and to conserve the higher grade fuels for use in industries where lower grade fuels cannot be used.

RATIONAL USE OF ENERGY IN THE SUGAR INDUSTRY: THE CUBAN EXPERIENCE

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INTRODUCTION

Solar energy is one of the major energy reserves available for Man, now on the threshold of the total depletion of fossil fuels, which had been utilized as the main energy source since he learned to use fire. However, by nature, it is not constant during the 24 hours of each day; it varies as a function of climatic conditions, and the ways in which it is received and transformed into useful forms has limited its use. The different ways of using solar energy may follow either of two approaches: one, which concentrates solar radiation by optical means to reach high-enough temperatures and quantities of energy; and one which takes advantage of the potential of solar energy to synthesize biomass through the metabolism of plants which, in turn, are used as fuels, in different ways.

Today many studies are being carried out to show the possibilities of different energy crops like sorghum, sugar cane, wood, etc. In this seminar we are concerned with the possibilities of sugar cane, which, even though it falls far short of fulfilling our total energy requirements, may make important contributions to the energy balance of our countries. The dry matter in sugar cane, when burned, frees 4,000 kcal per kg (7,200 BTU's per pound). On the basis of maximum agricultural yields, up to 200 million kcal can be obtained per hectare per year, equivalent to about 20 metric tons of oil. However, after analyzing the thermal efficiency of canesugar processing, including steam generation, we reach the conclusion that a first step in the utilization of sugar cane as an energy source is to take advantage of the reserves we have in our sugar factories. To demonstrate the potential of sugar cane processing is the aim of this paper.

The energy pattern of most sugar factories shows technical approaches dating from the beginning of this century. The Corliss engine had been defined as the best prime mover for cane mills, the main consumer of mechanical energy in the factory. Other types of steam engines were used for other purposes such as pumping, driving centrifuges and crystallizers, and even generating electric power, though for this purpose the use of the steam turbine became standard practice many years ago.

The design pressure and temperature of steam were those which resulted adequate for Corliss engines and for other alternative steam machines, i.e., with pressure in the range of 8 to 10 kg/cm^2 (120 to 150 pounds per square inch), with no overheating. Most of the existing cane sugar factories were designed with such thermodynamic steam conditions, allowing a good balance between requirements of high-pressure steam for prime movers and low-pressure steam for heating; no fuel was necessary other than the bagasse obtained from the cane.

During the last quarter of a century, many industries using bagasse as their main raw material had been established on the basis of the fact that the bagasse from the boilers of the sugar factory could be substituted by fossil fuel. However, with the outbreak of the energy crisis in 1973, the prices of fossil fuels, especially that of fuel oil, have increased very much, inducing a rise also in the price of bagasse. In order to tackle this problem, many enterprises started to improve sugar factory efficiency following more or less the experiences of the beet sugar industry, which never had waste to burn and which, even during the periods of low fossil fuel prices had to look for thermally-efficient means of processing. Afterwards, following an analysis aimed at efficient flow sheets, the specialists on this subject have found that the cane sugar industry cannot only deliver surplus bagasse, but also that by taking advantage of co-generation, it may be capable of delivering important quantities of electric power.

At present, outstanding engineering and design groups have a new concept of energy patterns for sugar factories, following new approaches oriented toward much more efficient solutions. A highly controversial point which has been raised is that of the pressure and temperature of live steam, since more efficient cycles for co-generation require inexcusably high values for these parameters. Further, during the last 30 years, technological developments in the engineering aspects of the sugar mill have broadened the horizons for solutions when handling this question of the high pressure and temperature of live steam. Examples of these developments are the use of steam turbines and modern electric drives in crushing mills; the use of extraction-condensing turbogenerator sets; and the development of high-pressure bagasse boilers.

Generating steam at high pressure and temperature and using efficiently the process steam makes it possible for the sugar factory, after fulfilling its energy requirement, to be in a position to deliver up to 25 kg of oil equivalent per metric ton of cane ground in the form of surplus bagasse and/or electricity, that is, half as much as that available in the bagasse.

It also becomes interesting to take into account the wastes of the crop which in most cases are lost or burned in the field. If somehow the wastes are brought into the balance, the potential for delivering energy is multiplied three-fold, since the content of dry wastes is twice as high as that of the bagasse. All in all, the cane sugar industry in GEPLACEA countries shows a potential savings of 22 million tons of oil.

ENERGY AND BAGASSE SAVINGS: SOME ALTERNATIVES

As can be inferred from the introduction, the improvements in the thermal efficiency of a sugar factory may be oriented so as to achieve surplus bagasse, surplus electric power, or a combination of the two. The selection of a concrete scheme will be strongly linked to economic and/or social objectives, such as to the growth of a sugar cane derivatives industry (especially one consuming bagasse) and to national energy policy.

The main aspects associated with the energy patterns of sugar factories and their improvements have been dealt with in specialized papers, seminars and conferences on sugar. New patterns have appeared in industrial practice, showing better efficiences in terms of economy; but due to the features in question, no optimal solution exists. There are various sound solution alternatives, depending on the objectives sought. We will not attempt to define the different alternatives; but starting from a special formulation of the problem, we will show the technical results of a set of given alternatives, among which the following may be considered extreme:

- maximum surplus bagasse, without surplus electric power
- maximum surplus electric power, without surplus bagasse.

It must be pointed out that both of these extreme solutions show high thermal efficiency; the difference lies in the objectives sought in each case: in the first one, bagasse as raw material for other industries;

and in the second one, generation of electric power for the national or regional grid, or for other special purposes.

Between these two extremes there exist an infinite number of alternatives, according to the relative weight given to surplus bagasse or surplus power. However, between these two, there is one which may be considered as the third main solution, that is, the generation of electric power by increasing the pressure and temperature of live steam up to technically-safe figures while using back-pressure turbogenerators sets, which means that only the quantity of steam required in process will be generated -- or, in other words, bagasse will not be burned to generate excess steam, over and above that required in process. Consequently, it should be condensed and this requires extraction-condensing turbosets instead of backpressure sets. This is the so-called co-generation in its unadulterated sense.

The industrial results of any one of these three main alternatives, or any other which may arise in that range, are given by a set of factors, among which the most important are: cane varieties, operational stability and discipline, and technical conditions of the equipment. For the purposes of this paper, the above factors may be passed over, assuming that the three have been solved adequately. Thus, we can concentrate on the main aspects of thermal efficiency, which control the results of any solution:

- efficiency of steam generation;
- efficiency in the use of process steam;
- pressure and temperature of live steam.

These three aspects are inter-related, and their relative importance and suitable levels are given by the main goals required by the energy pattern of the system and its technical and/or economic adequacy.

The ways to attain different results in each one of the above-mentioned aspects are known by industrial engineers and managers aquainted with the problem of energy in sugar production. The main features of each one are as follows:

Efficiency of Steam Generation

Boiler efficiency accounts for the biggest energy reserve in traditional sugar factories. In most of the old factories which still exist, boilers were supplied without elements for recovering sensible heat from flue gases (such as economizers or air heaters showing temperatures on the order of 300°C (572°F) and even higher), with the consequent losses involved in such designs.

The other important element associated with boiler efficiency is the type of furnace. Furnaces burning bagasse in a pile, as do the Dutch, Ward, Martin, etc., require a large amount of excess air over the theoretical figure, up to 100% and more. Furnaces with spreader stokers, introduced 30 years ago, require only a 30% air surplus, thus reducing the energy lost by heating the excess air from ambient temperature to that of the stack gases. Old or new boilers without these gadgets show efficiencies based on the low heating value of bagasse, on the order of 55-65%.

The utilization of economizers and/or air pre-heaters, or the recently introduced bagasse dryer, allows a safe reduction in stack gases (with no danger of corrosion), down to a minimum of 130°C (266°F). This, plus the utilization of spreader stoker furnaces makes boiler efficiencies increase to 85%; this aspect alone means a reduction in bagasse consumption on the order of 30%.

Efficiency in the Use of Process Steam

Old factories and, in many cases, new factories show a very low efficiency, investing between 550 and 650 kg of steam per metric ton of cane.

For many years, beet sugar factories, whose process parameters closely resemble those of cane sugar factories, have proven in practice (through more sophisticated schemes for the heating-evaporation-boiling system) that process steam can be reduced to 320 kg per metric ton of beet. Use of vapor bleeding in evaporators, for heating and boiling; the use of a high number of effects, five and even six may today prove economical; and sometimes the substitution of the throttle valve by other balancing elements such as vapor-cells or thermocompressors -- these are elements which permit increased efficiency. This has already been proven in cane sugar processing, yielding practical values as low as 370 kg of steam per metric ton of cane. This reduction in process steam may lead to a reduction in bagasse consumption on the order of 25%.

Pressure and Temperature of Live Steam

The generation of one metric ton of steam at high pressure and temperature (85 kg/cm^2 (1 250 lb/in^2) and 400°C (750°F), for example) requires the same quantity of fuel (bagasse) as the generation of one ton of steam at 9.5 kg/cm^2 (140 lb/in^2) and 327°C (620°F). Steam with the above "high" conditions may generate about 130 kWh, while the "low" conditions may generate only 57 kWh; thus, with the same bagasse burned in the boiler, the amount of power generated can be more than doubled merely by raising the pressure and temperature of the steam.

The above example is enough of an argument of the electric power that can be obtained by going to high conditions of live steam.

The three aspects described above form the framework through which the thermal efficiency of sugar factories may be increased for delivering surplus bagasse and power. The steps taken toward achieving this goal may not be easy to execute, and may even be of doubtful feasibility in some cases. The main obstacle in the path of such increases in efficiency is the fact that the cane sugar industry reached a plateau in its technical development more than forty years ago, and the changes that are now necessary are not easily accepted by the industry.

In order to study the three main alternatives outlined previously, many flowsheets were prepared, and material and energy balances calculated with the aid of a computer. With the results, the data for the different alternatives were graphed, as included herein.

Surplus Bagasse

Due to current fossil fuel prices, the policy of burning such fuels in a sugar factory, to free bagasse for use as raw material in other industries, may induce high costs for the end-products in these industries, which in many cases may become uneconomical. It is easy to show that, in general, it proves more economical to remodel the sugar factory in order to get as much surplus bagasse as possible. A bagasse market can be expected to develop. Today, the transportation of bagasse in bales or in other compacted forms, such as pellets, cubes, etc., has proven to be technically and economically viable.

The upper half of Figure No. 1 depicts lines showing the surplus bagasse which may be obtained as a function of process steam in the factory for different boiler efficiencies. It can be seen that, if we have a situation where we are using 53 kg of heating steam per 100 kg of cane (a typical index in Cuba's old factories) and where boiler efficiency is 58%, no surplus bagasse is produced; this is the present situation in most Cuban factories. Now if we increase boiler efficiency up to 78% but we do not do anything else in the steam cycle, the immediate result is that we get about 27% of surplus bagasse.

In Figure No. 1 we can also see the influence of the efficiency of exhaust steam used as a heating medium. If we decrease this index from 53%, the usual value for Cuban factories, down to 40%, and if we have boilers with a 78% efficiency, surplus bagasse increases from 27% to 43%.

As far as reductions in the index of heating steam per cane processed is concerned, it is necessary to analyze the whole cycle since steam goes through the prime movers to the process as the heating medium, and when coming through the machines, it delivers the total mechanical (electrical) energy required in the factory. Thus, when improving the efficiency of steam use in process, it becomes necessary to increase the steam conditions as generated in the boiler, in order to guarantee satisfaction of mechanical energy demands in the factory.

The lower half of Figure No.1 depicts lines showing the dependence of the temperature and pressure of high pressure steam as generated, for different steam-heating demands. In this figure it can be seen that at the normal index of 53 kg of steam per 100 kg of cane, common in Cuba's old factories, the pressure required at the entrance of the machines is on the order of 8.0 kg/cm^2 (120 lb/in^2) and temperature is close to that corresponding to saturation.

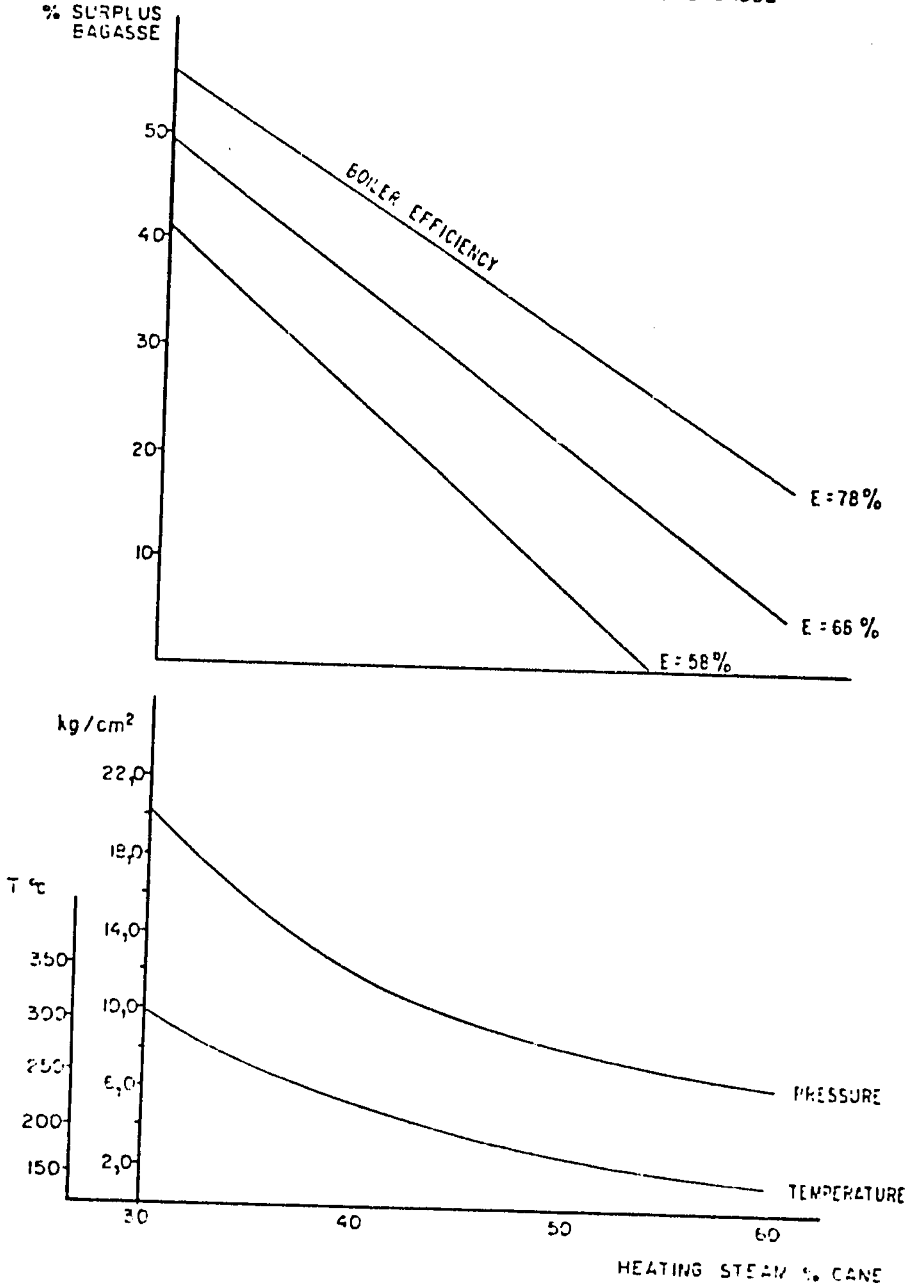
Co-generation

Between the approaches of maximum surplus bagasse and maximum surplus electric power, there is the alternative of co-generation, pure and simple, that is, generation of electric power at the maximum value possible with process steam, without burning bagasse to produce additional steam over and above that required in process, for this would entail the use of extraction-condensing turbogenerator sets. This goal can be achieved by increasing the pressure and temperature of live steam to the maximum allowed by techno-economical conditions.

In Figure No. 2 the computations for four typical conditions of steam in the world sugar industry have been graphed. The electric power values shown are those obtained after subtracting the demand of the factory. An example will aid in understanding this alternative.

With a demand of 400 kg of process steam per metric ton, that is, heating steam equal to 40% cane, under conditions of 18 kg/cm^2 and 343°C, 39% of the total bagasse produced can be obtained as surplus.

FIG. Nº 1 SURPLUS BAGASSE



Additionally, 8 kWh per ton of cane can be obtained as surplus power. If the live steam conditions are increased to 58.8 per cm^2 (850 psig) and 454°C (850°F) with the same process steam demand as before, the surplus bagasse obtained is on the order of 35% of that produced, and power delivery 29.5 kWh per ton of cane. The additional 21.5 kWh per ton of cane are produced from an increase in burned bagasse (about 12 kg or 2.2 kg of oil equivalent), which means about 106 g per kWh, a value much lower than the best obtained in oil-based thermoelectric plants (220-240 g oil per kWh).

Co-generation is an efficient way of producing electric power and, at the same time, it permits important quantities of bagasse for use as raw material in other industries.

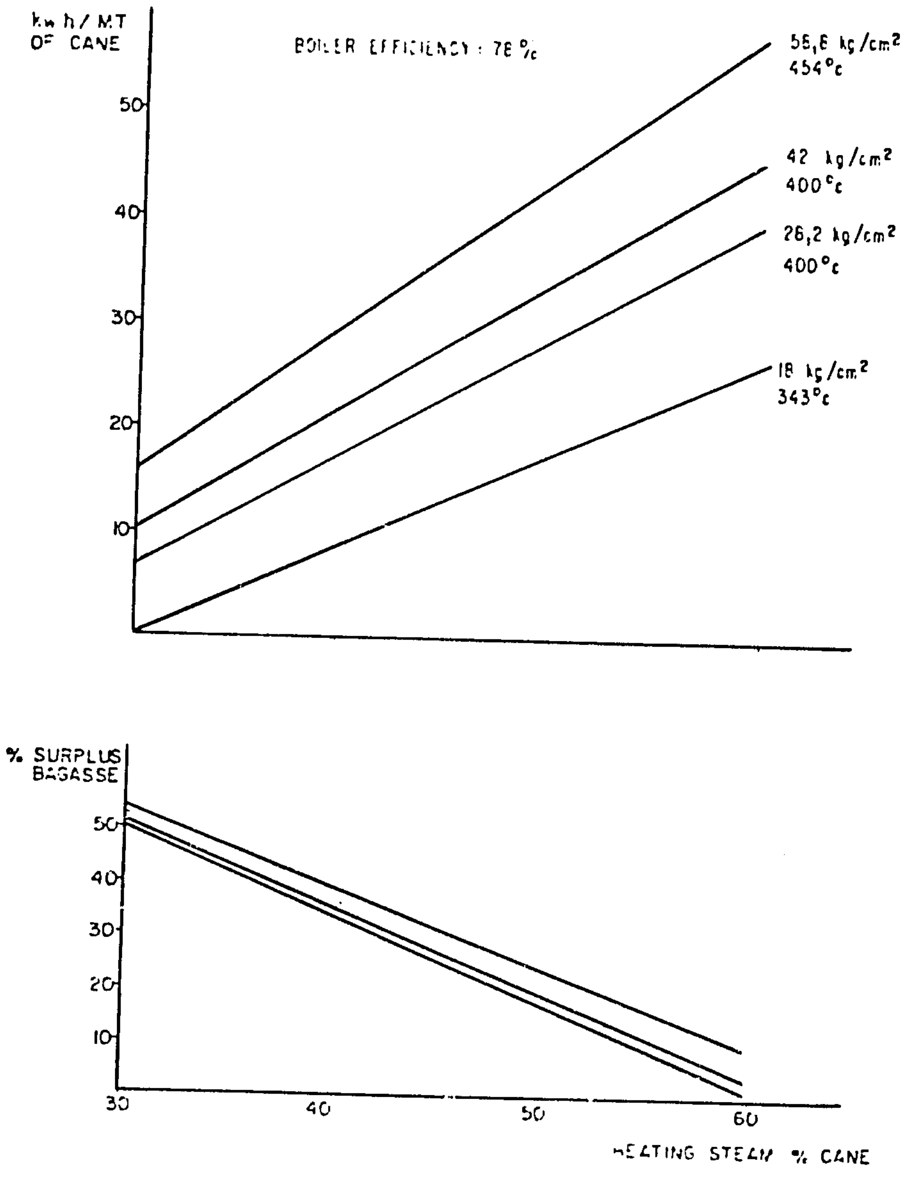
In Figure No. 2 many combinations are shown. It can be seen that as the interest in electric power increases, the efficiency requirements for the use of process steam will be lower. The large direct influence of the pressure and temperature of steam on surplus power can also be seen, with the optimum being determined by investment and operational considerations; and, inversely, there is a low influence of the pressure and temperature of steam on surplus bagasse.

One last worthwhile note is that when moving to the right along the line from zero surplus bagasse, up to the lines corresponding to different steam conditions, the points of intersection represent the maximum surplus electric power that can be delivered without using extraction-condensing turbogenerators.

Surplus Electric Power

The case of surplus electric power is that in which no surplus bagasse is obtained. The main question in this case is how to reduce the heating steam's percentage of cane as much as possible so that what could be obtained as surplus bagasse would be burned to produce excess steam over

FIG. Nº 2 CO-GENERATION



and above that required for heating, steam which would then expand in condensing turbosets.

The calculation of surplus power for four levels of steam conditions are shown graphically in Figure No. 3. The lines coming up to the right show the surplus power generated with process steam and the lines coming down show the total surplus power generated.

Both lines of every steam condition are cut where the heating steam's percentage of cane is the total that can be generated with the bagasse produced.

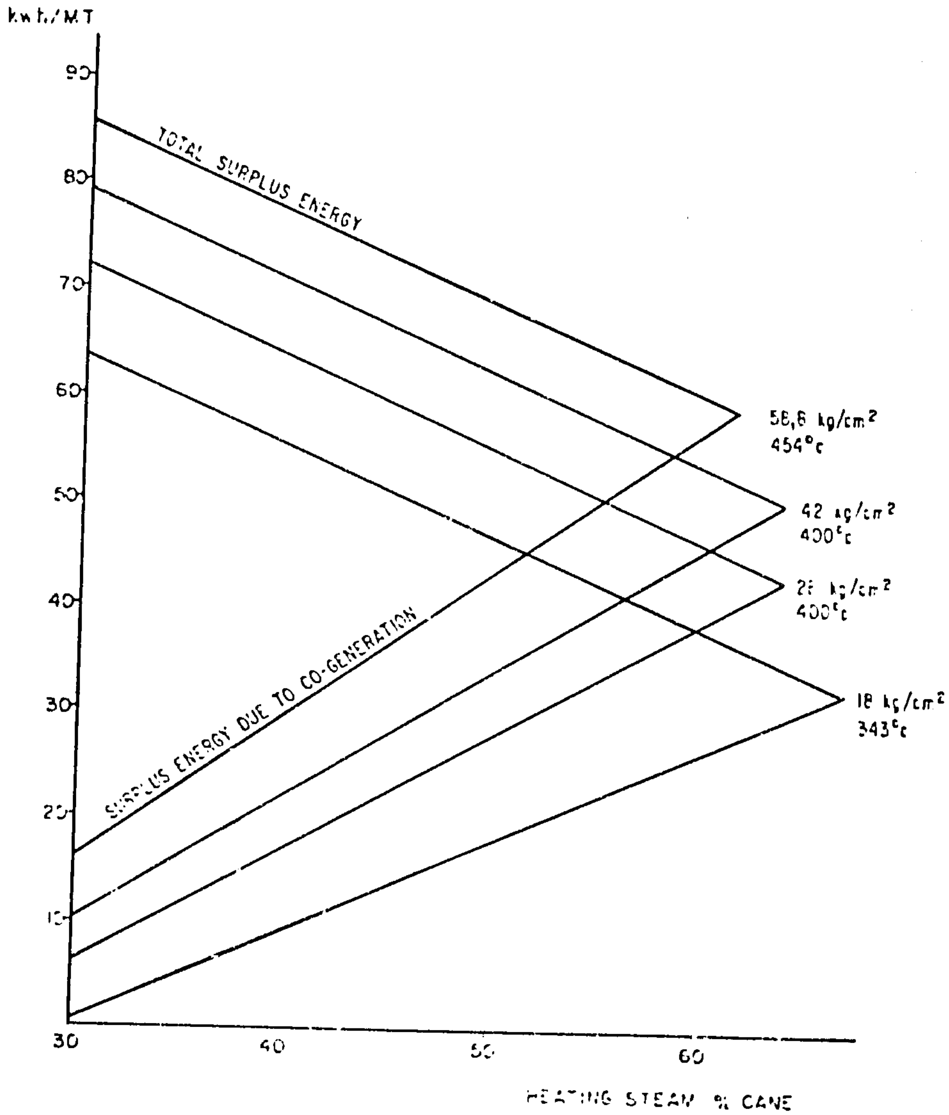
Taking as an example the same case we saw in the co-generation alternative, it can be seen that at 58.8 kg/cm^2 and 454°C, 29.5 kWh per ton of cane can be produced by co-generation and 76.5 kWh per ton of cane if all the bagasse produced is burned. The additional power generation from the 35% surplus bagasse we should get with pure co-generation. It means that these additional 47 kWh per ton of cane are produced at a rate of oil equivalent of 440 g per kWh, about 60% higher than in modern, efficient oil-based plants.

The economic analysis of this alternative strongly depends on macro-economic criteria, so it is needless to delve any further into our analysis.

STEPS TAKEN AND THE CURRENT STATUS OF THE ENERGY COOPERATION PROGRAM AMONG GEPLACEA MEMBER COUNTRIES

The Cooperation Program on Energy from Sugar Cane was the result of a seminar on Rational Use of Energy, held in Havana in October 1980. During this event, sponsored by GEPLACEA, UNIDO, OLADE and the Cuban Ministry of Sugar, the need to create a center of applied research was set forth. This center would study and develop, in an integrated way, the energy potential of sugar cane.

FIG. Nº 3 SURPLUS ELECTRIC POWER



In view of the importance of the subjects dealt with during the seminar, the Secretariat of GEPLACEA decided to carry out a study on the possibilities and outlook for the transformation of energy in sugar factories. A document known as " Sugar Cane as an Energy Source " was prepared by experts from ICINAZ, Cuba; " La Victoria " Sugar Corporation, Panama; and the Latin American Energy Organization (OLADE).

One of the resolutions adopted by the General Assembly was to convene a meeting of high-level experts, for the purpose of analyzing the possibilities of implementing a regional program of energy cooperation. This meeting was held in Mexico City during July 23-30, 1981, with the presence of representatives of Brazil, Costa Rica, Cuba, Ecuador, Guyana, Mexico, Panama, the Dominican Republic and the following organizations: UNIDO, OLADE, IICA, and GEPLACEA.

The first meeting of the Commission took place in Havana during January 28-30, 1982. All its members attended, except Brazil; and the delegates discussed the activities to be carried out in each country.

The Secretariat has made great efforts to find more dynamic ways to implement the project. Up to now, however, the only definitions arrived at, among a number of tasks, refer to the dates for seminars to be organized on Biogas and Fuel Alcohol. The seminar on Fuel Alcohol will be sponsored by GEPLACEA, OLADE, and Brazil's IAA. Its date has already been set, and a program of activities has been prepared.

The cooperation offered by OLADE at all times, in every activity emanating from the program, deserves special mention. From the first, a close relationship has existed between GEPLACEA and OLADE. One tangible example of this cooperation is the financial support received from OLADE, through the Latin American Energy Cooperation Program (PLACE), for the organization of seminars on Biogas and Fuel Alcohol and for the execution of the Project on Rational Use of Energy in the Dominican Republic.

CONCLUSIONS

In this paper, three major alternative uses of energy reserves from the sugar industry have been analyzed. These alternatives may be oriented to the development of cellulosic pulp industries using begasse as raw material or may contribute to the supply of power to the electric grid. In both cases the increase in efficiency may induce important contributions to the national economy in countries such as Cuba, the Dominican Republic, and other countries or regions where sugar production per capita is significant.

Co-generation shows the most economic way of generating surplus power for other uses or for the grid, while delivering important quantities of surplus bagasse. It may be conceived as the most economic solution when considering the development of a derivatives industry in a sugar cane region with a high concentration of sugar mills and a long sugar season. Power is produced in the most efficient, lowest-cost way, while bagasse is supplied for the total requirements of the region. The balance is achieved through a suitable analysis of the particular case under study.

The generation of surplus power using extraction-condensing turbines depends on macroeconomic criteria concerning the relative value given to bagasse as raw material for industry or as fuel for saving oil. In countries such as Mexico and Venezuela, which have large reserves of oil at their disposal, and low domestic oil prices, this alternative is not attractive since it does not compete with fuel oil; but in countries where the usual present high prices of fuel oil prevail, it proves to be economical.

The Problem of Energy Savings in Sugar Manufacturing

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The Overall Picture

1. GENERAL

Although energy costs represent a mere 7% of the total cost of sugar manufacturing, this sector as a whole is the fourth largest user of fuel oil and one of the lowest in electricity consumption, being approximately 93% self-supplying.

This sector's energy consumption, some 2.5% of total industrial energy use, averages about 600,000 tons of oil equivalent.

Spain currently has the productive capacity to supply its domestic sugar market, although at times some sugar has been imported. During the 1979-80 season, a total of 882,460 tons of sugar were produced: 862,160 tons from sugar beets, and 20,300 from sugar cane.

Thirty-three sugar mills operate in our country, 31 of which process only sugar beet, whereas two process both sugar beet and cane. Figure 1.0.1. shows the geographical location of these facilities.

1.1 The Impact of Fuel Costs on Sugar Production Costs

As shown in Figure 1.3.2., fuel (with subsidized prices) played a progressively minor role in total costs until 1972, when with the crisis they began to climb rapidly to this year's approximate cost of 7.0 pesetas per kilogram of sugar.

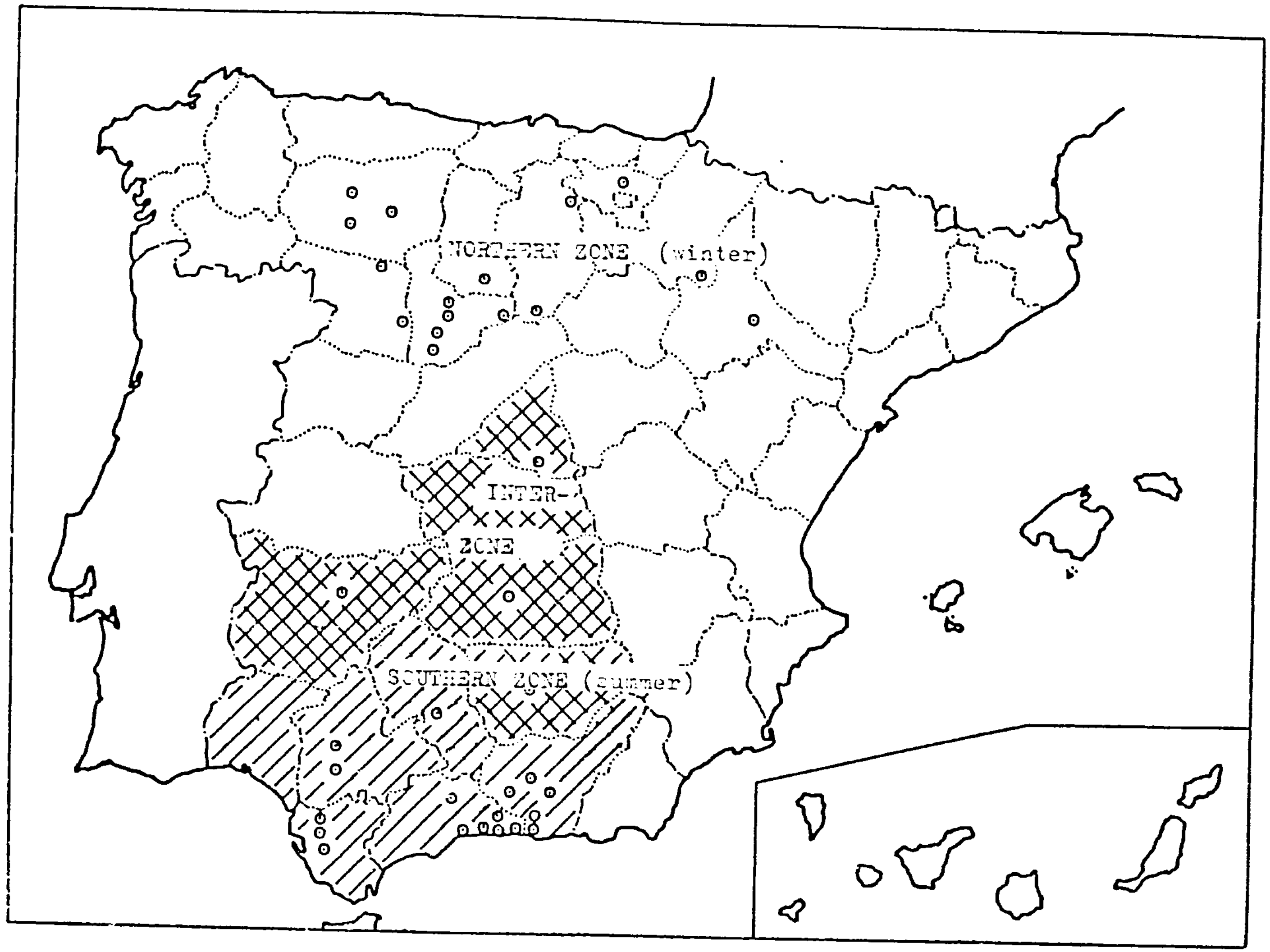


Figure 1.0.1 Geographical distribution of sugar mills

Figure 1.2 Production Flowchart for the Northern facilities.
(All amounts based on an input of 100 kg of sugar beet.)

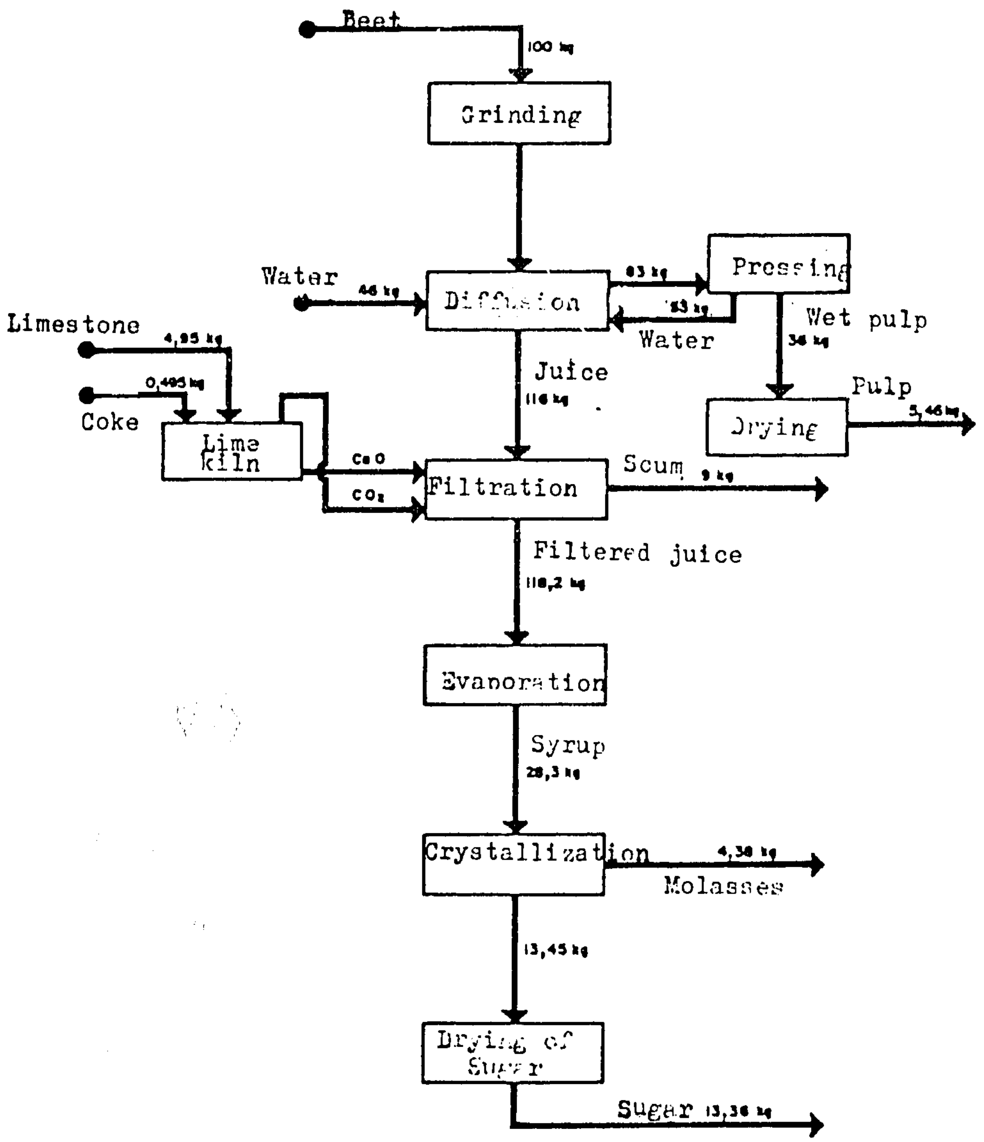
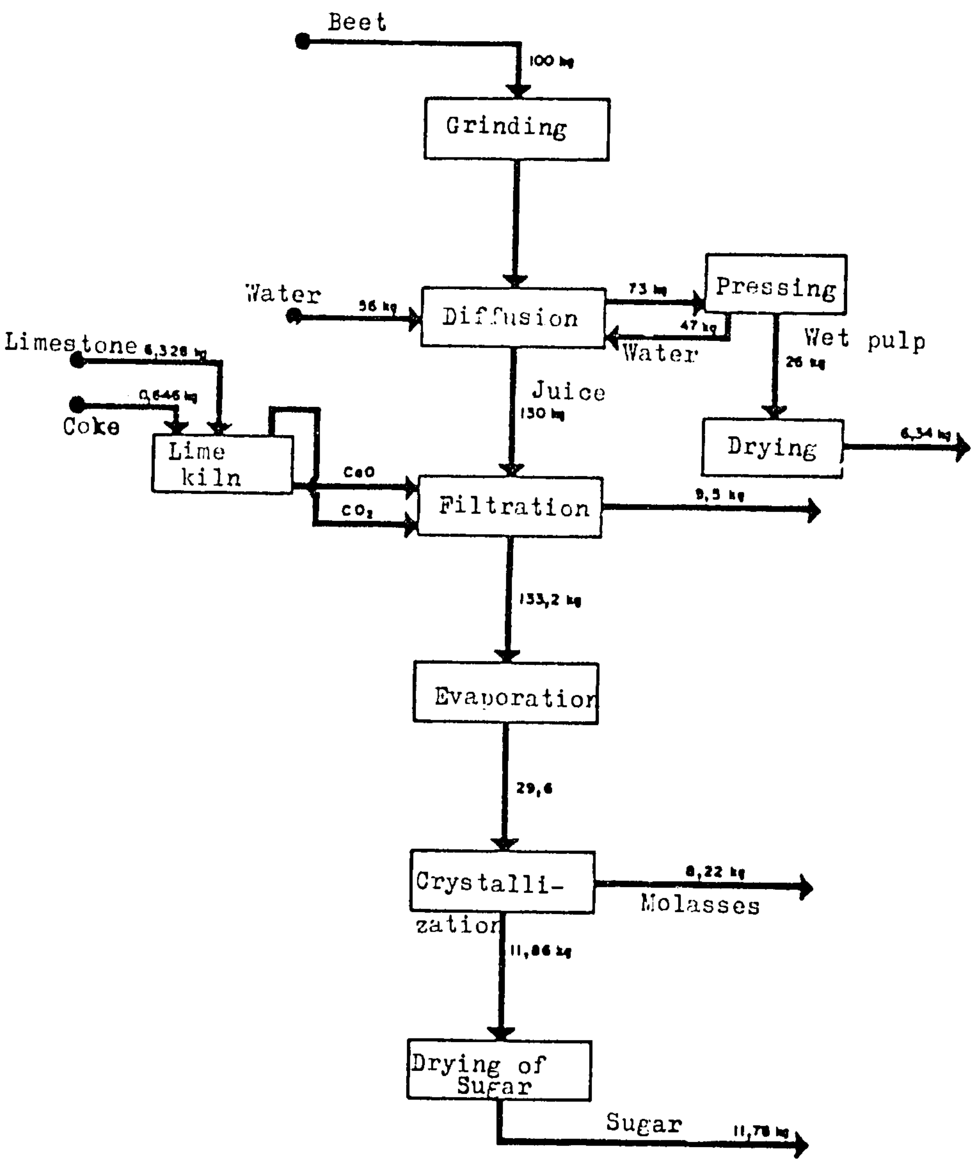


Figure 1.3 Production Flowchart for the Southern facilities
(All amounts based on an input of 100 kg of sugar beet.)



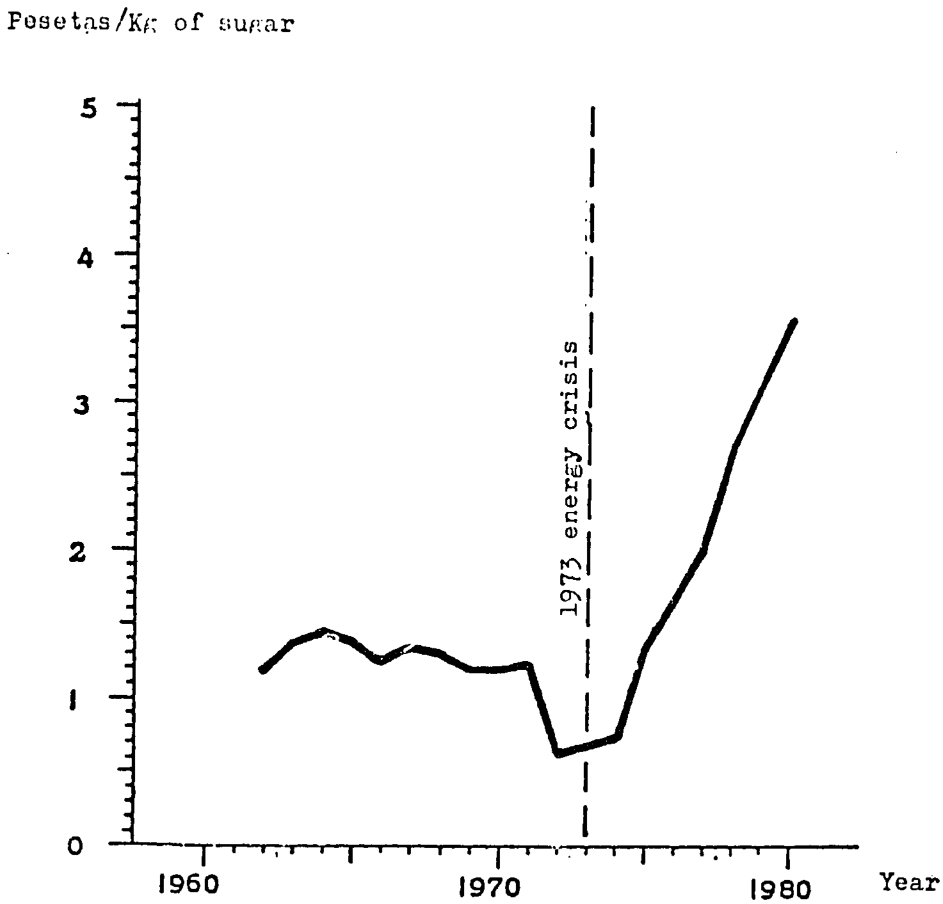


Figure 1.3.2. Evolution of sugar production energy costs

Pesetas/Kg of sugar

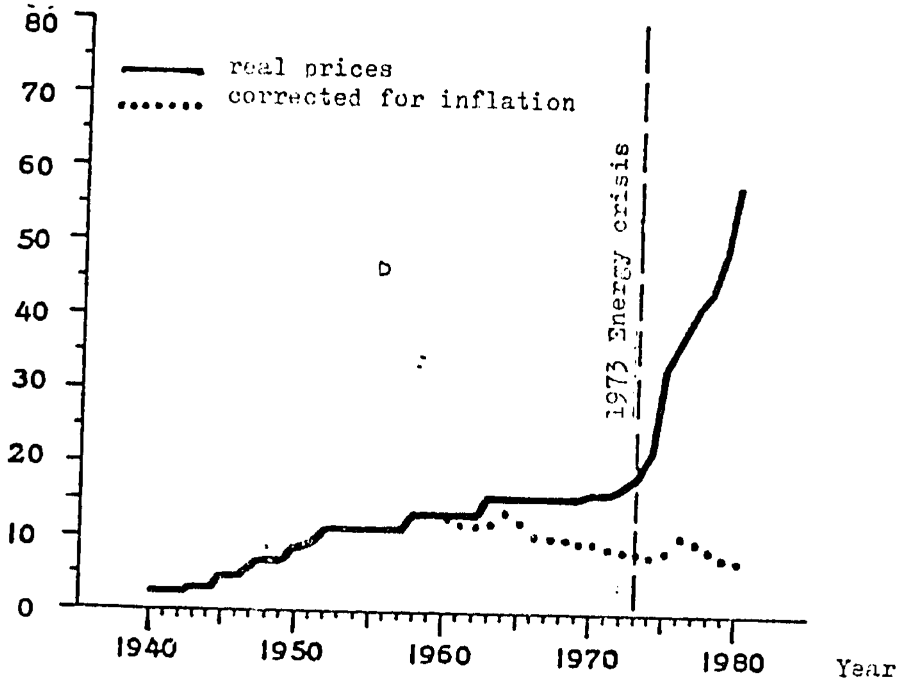


Figure 1.3.3. Evolution of sugar prices

Figure 1.3.2. also shows that while sugar prices rose, in real terms they were dropping, although very slightly. This tendency is now being corrected and the prices for the 1982-83 season have regained a stable level.

This justifies an energy-saving policy for the sugar sector.

2. SAVINGS AND INVESTMENTS

2.1 Energy Savings

First of all, it should be pointed out that no electricity savings have been analysed in these studies; thus, the savings in primary energy and direct consumption coincide with those of thermal energy.

The energy savings statistics, including their frequency distribution, were as follows:

Firms studied	19
Total savings	16,318.3 toe
Average savings	858.86 toe
Standard deviation	894.53 toe
Highest figure	3,501.8 toe
Lowest figure	83.0 toe

Without taking into account the amortization periods, dealt with in Section 2.2, when the individual ratios are calculated for actual improvements made, the investment required to achieve the 16,318.3 toe savings totalled 306 million pesetas.

2.2 Improvements

The energy saving improvements made have been grouped as follows:

- Improvements in boilers;
- Improvements in dryers;

- Improvements that decrease specific consumption by recovering sugar from molasses;
- Improvements in evaporation chambers;
- Other improvements.

2.2.1 Improvements in Boilers

This heading also includes all improvements regarding steam-generation equipment.

Upon verifying the status of this equipment, many boilers were seen to be working with a considerable excess of combustion air. However, under present conditions the elimination of this excess of air could entail the appearance of unburnt residues. To avoid this, while optimizing combustion conditions, 11 of the 19 facilities studied have proposed the replacement of their burners.

For the change of burners to be fully effective, other concurrent modifications are foreseen; these vary according to the facility involved. The most common are:

- improvement in the regulation and control equipment;
- use of pre-heated air for combustion;
- revision of boiler piping.

Consequently, the increased yield is accompanied by increased boiler capacity and, above all, greater reliability of service - both difficult to appraise precisely.

Table 2.2 provides data on savings and investments needed to put the improvements into practice.

None of the firms have put forth the possibility of raising the working pressure of its boilers, although this is technically possible in several cases.

Under the heading "Limits to the Production of Electricity", the tendency to reduce steam consumption while increasing the consumption of electricity would seem to be recommendable. The fact that no firm has proposed it may be due to the present structure of the electricity market.

This structure discourages the sale of the energy surpluses that firms would have if they applied this improvement. The result is that a significant quantity of electricity, at the excellent yield of 0.13 kg of fuel oil/kWh, is not being produced.

Even the increased production that would make plants self-supplying is not profitable for many, because any problem during harvesting that would oblige them to connect up with the general system would mean that they would be billed for minimum rates, which it is naturally preferable to consume.

Table 2.2

Improvements by Replacement of Boiler Burners

Facility	Savings (toe)	Investments (in thousands of Pesetas)	Amortization (Months)	Amortization (Seasons)
1	456.9	6,250	24	2
2	240.0	2,500	18	1.5
3	174.9	2,750	27	2.2
4	256.3	3,250	20	1.8
5	208.3	3,250	24	2.4
6	262.1	2,750	18	1.5
7	223.3	3,250	25	2.1
8	358.8	3,000	14	1.2
9	263.0	2,700	17	1.4
10	313.0	7,000	36	3
11	460.0	5,200	19	1.6
	3,216.6	41,900	22	1.8

In order to put to use the exhaust gases, which in some cases come out at high temperatures, the installation of economizers and combustion air pre-heaters in the boilers has been proposed as an improvement. Other companies have proposed the use, in dryers, of hot fumes from the boilers, as described under heading 2.1.1. Table 2.3 gives the data regarding the energy savings and investments required.

Table 2.3

Other Improvements in the Boilers

Improvements	Firms	Savings (toe)	Investments (in thousands of Pesetas)	Amortization (Months)	Amortization (Seasons)
Economizers	1	340.9	8,000	43	3.6
Economizers	2	66.2	3,650	95	7.9
Pre-Heaters	3	903.0	14,600	28	2.3
Pre-Heaters	4	90.2	7,300	139	11.5
Pre-Heaters	5	801.8	9,100	19	1.6
Pre-Heaters	6	345.6	6,500	32	2.7
		2,546.7	49,150	33	2.7

2.2.2 Improvements in Pulp Dryers

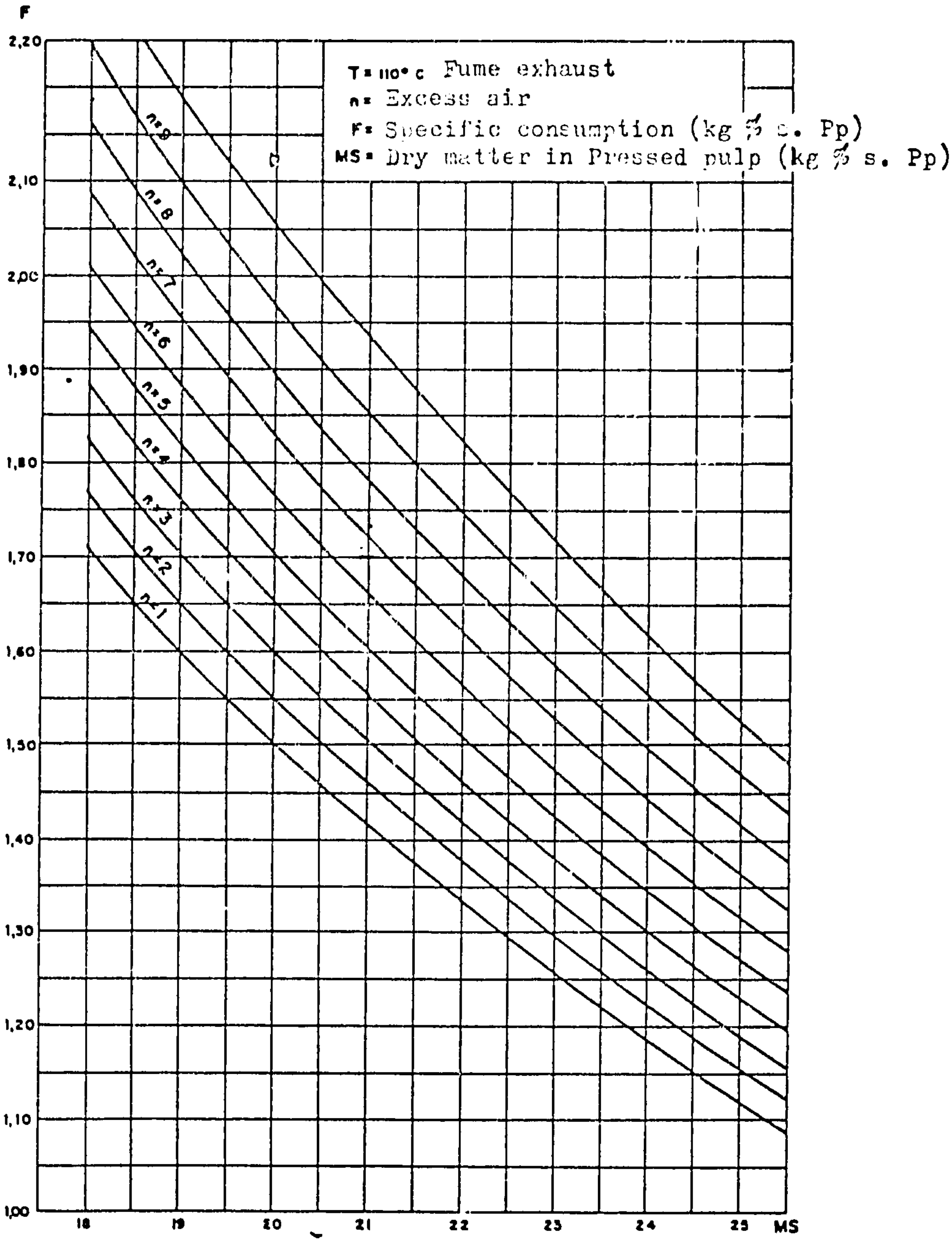
This heading comprises all the improvements that directly or indirectly lead to energy savings in the pulp dryers.

The costliest improvement is replacement of chamber-type dryers by rotating drum dryers.

In the rotating dry-kilns, the hot gases contact the wet pulp very quickly and thoroughly. Under these conditions, the initial drying gas temperature may be quite high, in the order of 800 - 900°C, with no pulp burning losses. Consequently, the ratio between the actual combustion air and the stoichiometric air may be very low (under 3). This favourable ratio may be improved by using (oxygen-poor) boiler fumes to temper the drying gases, for in this event the initial temperature could be raised up to 1000°C.

The gas temperature must be reduced in chamber-type dryers for various reasons, such as the lower temperature tolerance of the drums and blades, and the lesser initial contact of the gases with the entire body of pulp. This increases dilution to the point of having n values of 4 or 5. Figure 2.1 shows the influence of n on the theoretical specific consumption as a function of the MS (% of dry matter) of the pulp. This graph also shows the importance of replacing vertical pulp presses with horizontal presses, an improvement dealt with below.

Figure 2.1 Specific pulp-drying fuel oil consumption as a function of MS and n.



Given the lengthy amortization period that they entail, these improvements may be introduced gradually as equipment is renovated or expanded.

To take advantage of hot boiler exhaust gases, four facilities have proposed the use of these in the dryers as an improvement. These gases take the place of the ambient dilution air and use their enthalpy to reduce the dryer's consumption accordingly. Table 2.4 shows the savings and investment figures as well as these improvements' amortization periods.

The recycling of boiler exhaust to dryers has significant advantages:

- Reduction of the fuel consumption required to obtain the drying gases:

  Figure 2.2 shows the quantity of combustion fumes with 15% excess air that is required to produce 100m3 of drying gases at 800°C as a function of the dilution fume temperature. This figure also shows the percentage of fuel required, with 100 as the base used when tempering with 20°C air. As the graph indicates, with 250°C fumes, the consumption in dryers may be reduced by 20%.

- Decreased air pollution;

- The pulp has the property of capturing the SO_2 and SO_3 from the combustion gases, thereby producing a beneficial bleaching effect and preventing sulphur pollution;

- Reduced economizer corrosion, because the gas temperatures remain relatively high;

- The main stumbling-block in the way of using boiler exhausts in dryers is that the two facilities may be so far from each other that ducting costs would be prohibitive and fumes would cool on their way.

Figure 2.2 Combustion gases and fuel consumption for 100 Nm^3 of 800°C drying gases

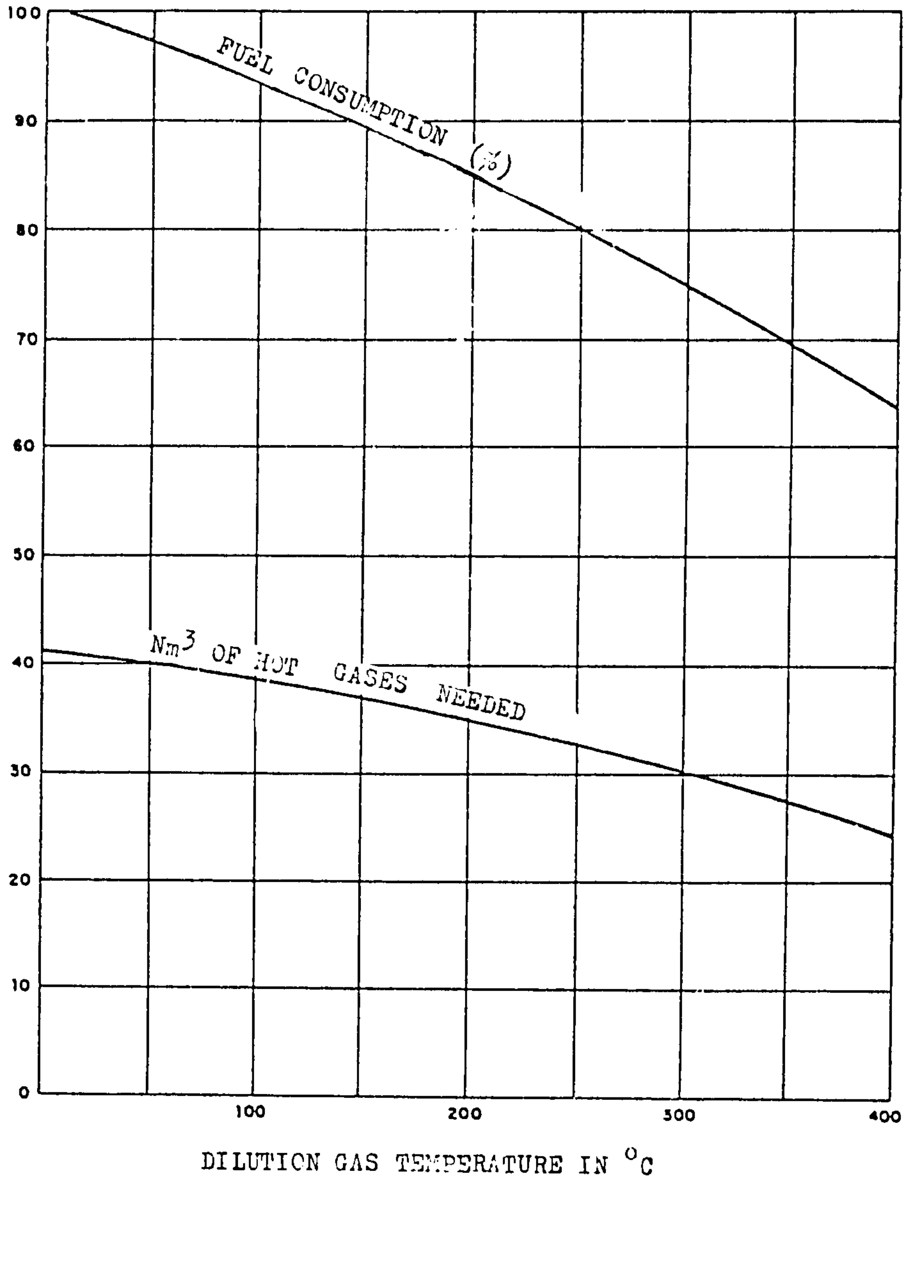


Table 2.4

Improvements in Dryers

Type of Improvement	Savings (toe)	Investments (In thousands of Pesetas)	Amortization (Months)	Amortization (Seasons)
Replace chamber-type by Rotary	1,665.6	59,000	60	5
Replace chamber-type by Rotary	738.8	29,000	67	5.5
Boiler exhaust to Dryers	521.9	8,000	26	2.2
Boiler exhaust to Dryers	585.5	8,000	24	2
Boiler exhaust to Dryers	616.0	17,750	52	4.1
Boiler exhaust to Dryers	1,741.0	40,900	44	3.6
Replace Press	392.6	1,500	7	0.5
Replace Press	216.5	1,500	12	1
Replace Press	163.0	1,500	16	1.4
Replace Press	254.4	1,500	12	1
Replace Press	192.0	1,500	14	1.2
Substitute Presses	1,355.0	26,300	37	3
Regulation of Press Speed	189.5	600	6	0.5
Drum Insulation	256	800	6	0.5
Drum Insulation	256	800	6	0.5
Drum Insulation	83	1,000	17	1.5
Drum Insulation	61	900	24	2
Control Equipment	182.7	1,233	24	2
Control Equipment	685	4,745	12	2.9
	10,155	206,528	35	2.9

The concentration of dry matter in the pulp leaving the presses greatly affects the dryers' fuel-oil consumption: the higher the dry matter content, the less water to evaporate. Whereas vertical presses yield a 16% dry matter content, horizontal presses can attain dry matter contents near 24%.

Six of the plants studied propose the replacement of their vertical presses by horizontal ones. In the plants that already have horizontal presses, the proposal is to overhaul them or regulate their speed to increase the dry matter content. Table 2.4 shows the savings and investment figures.

Conditions of the sugar beet itself and of the process also affects the percentage of dry matter in the pulp. A poorly cut beet or diffusion at excessively high temperatures or with the pH too low, produce a pulp which is difficult to press and which retains too much water, even when highly efficient horizontal presses are used. Therefore, in addition to replacing obsolete presses, the operating conditions must be closely examined in order to ensure the most favourable results.

New techniques currently being researched must also be considered to reduce the moisture content of the pulp entering the dryer. One technique of special interest is the centrifuging of the pulp, which seems to promise 40% dry matter.

The remaining improvements related to dryers (Table 2.4) have to do with the insulation of the drums, since their large surface areas allow considerable heat losses.

The table on dryer improvements also includes two improvements in their instrumentation and control.

Although these studies have assigned fuel savings figures, these improvements are fundamentally aimed at maintaining optimal operating conditions.

2.2.3 Improvements that Decrease Specific Consumption by Recovering Sugar from Molasses

Table 2.5 gives the sugar yield as a function of the beet's sugar content, as well as the ratio between the molasses and the sugar produced.

Table 2.5
Ratio Between Sugar Produced and
the Ratio Between the Sugar Content in Beets and Molasses

	National Average	Northern Average	Southern Average	Best in Spain
Sugar Produced/Sugar in beets	0.788	0.829	0.715	0.861
Molasses/Sugar	0.465	0.328	0.719	0.29

We can see that the Southern facilities produce much more molasses than the Northern plants, and that the sugar produced/sugar in beets ratio is much lower in the South.

The present molasses sugar content in Southern plants is from 45 to 50% of the sugar production (one of the Southern firms has figures similar to those of the North because it uses a system of sugar recovery from molasses).

There are two ways to recover the sugar currently lost in the molasses.

The first is the total demineralisation of the juices. This system would justify itself completely if it allowed the Southern facilities to approach the average levels of the Northern plants.

However, the true economic drawbacks to this change are:

- the uncertainty of the actual recovery level;
- the high reagent consumption;
- the production of residual waters.

Since molasses formation has very complex causes, it would be advisable to study the advantages in demineralisation experimentally before embarking on this possible improvement.

The second sugar recovery procedure consists of ionic treatment of the molasses.

The most common process replaces the monovalent Na^+ and K^+ ions in the second-run molasses with Mg^{++}.

One plant in the south is now treating its second-run molasses and has reduced its molasses production.

These operations increase the white sugar yield index, thereby lowering the energy cost per unit of product.

Table 2.6 lists the estimated figures for investments, molasses production, and decreases in specific energy consumption for four plants that have proposed this investment.

The economic results are quite favourable since the profits from the sales of the higher sugar production repay the investment in a single season, making the amortization then less than one season.

Nevertheless, the process yield should be tested experimentally before undertaking such improvements to determine whether the yield will actually approach such levels and if the operating costs do not make the process prohibitive.

2.2.4 Replacement of the Calender Tubes of the Evaporation Chambers

The replacement of the calenders of the last evaporation chambers by stainless steel tubing (more recommendable in the Southern sugar mills, where juice is more prone to form deposits in the tubes) leads to savings in several areas.

Table 2.6

Sugar Recovery from Molasses

	Inst.	Molasses/Sugar Current	Molasses/Sugar Foreseen	Investment (millions of Pesetas)	Largest Sugar Production	Specific Consumption: Current (Th/t az)	Specific Consumption: Foreseen (Th/t az)	Specific Consumption: Reduction in Sp. Cons. (%)
Total demin. of juice	1	0.746	0.38	168	14.000	3,616.4	2,868.2	20.69
Treatment of syrups	1	0.746	0.38	185	14.000	3,616.2		20.69
Total demin. of juice	2	0.73	0.384	168	14.000	2,929.0	2,342.7	20.02
Treatment of syrups	2	0.73	0.384	185	14.000	2,929.0	2,342.7	20.2
Total demin. of juice	3	0.75	0.473	87	6.150	4,356.9	3,367.7	22.70
Treatment of syrups	3	0.75	0.473	98	6.150	4,356.9	3,367.7	22.70
Total demin. of juice	4	0.85	0.527	106	5.800	4,620	3,815.4	17.42
Treatment of syrups	4	0.85	0.527	100	5.800	4,620	3,815.4	17.42

- Less sugar loss in the first chamber, due to lower temperature of the juice;
- Less labour required for chamber cleaning;
- Larger useful transmission surface, throughout the season;
- Greater electrical production, due to lower back pressure.

The overall worth, and therefore the profit ratio, on the investment is difficult to determine; but the modification lends operating security to the facilities, which may compensate for the lack of profitability.

Of the facilities studied, eleven have proposed this type of improvement.

2.2.5 Other Improvements

This heading includes all improvements in general that have not been included in the previous groupings.

Among the general improvements, three of the 19 plants have inspected and improved their facility's insulation.

Table 2.7 shows the corresponding figures for savings and investments.

Table 2.7

Other Improvements

Improvement	Savings (toe)	Investments (in thousands of Pesetas)	Amortization (Months)	Amortization (Seasons)
General inspection of insulation	122.4	1,620	24	2
General inspection of insulation	83.6	630	13	1
Fuel tank insulation	193.5	5,472	48	4
Totals	399.5	7,722	33	2.7

Another type of improvement presented is the evaluation and installation of instrumentation and control equipment throughout the plant.

Sixteen of the 19 plants studied have undertaken this type of improvement. While a profit ratio cannot be directly assigned, the immediate advantage consists of greater ease in controlling the plant and keeping it in top working condition.

2.3 Correlations

With the study data, the savings, investments and amortization periods have been correlated, yielding curves which have been adjusted according to the series of original points. The curves obtained appear in Figures:

- 2.3 Savings/amortization period/investment ratio
- 2.4 Investment/amortization period ratio
- 2.5 Investment/% of savings ratio.

3. FINAL CONSIDERATIONS AND RECOMMENDATIONS

3.1 Relations with Other Industrial Sectors

In most cases, the sugar industry operates in isolation, far from other industrial facilities, and with no interdependent relationship to these.

The only point of contact with other industries is established in the use of molasses, which is normally fermented to produce ethyl alcohol. Spain has several alcohol plants which ferment molasses.

Molasses is also used as raw material in the manufacture of citric acid and other products (phthalic acid, yeasts, etc.).

Figure 2.3 Savings/amortization period/investment ratio

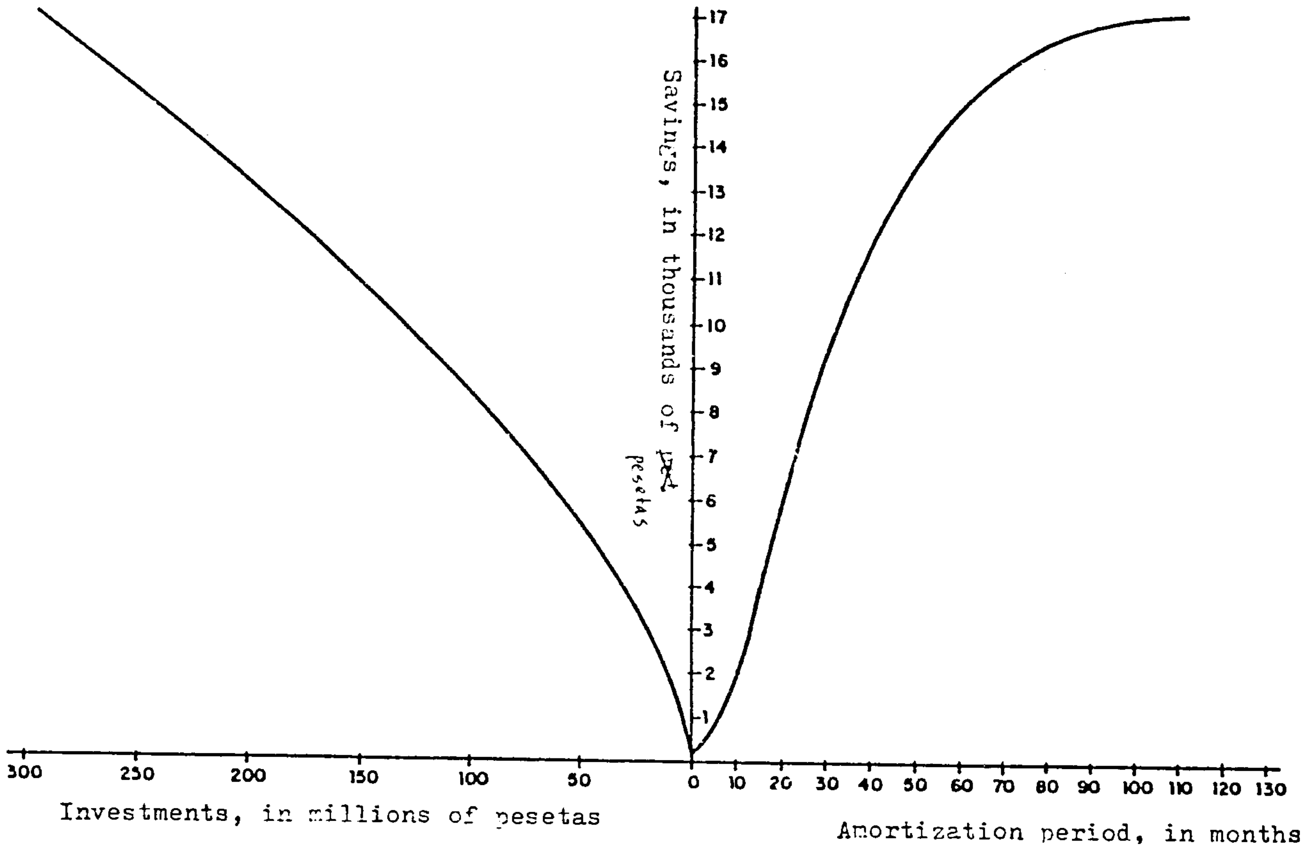


Figure 2.4 Investment/amortization period ratio

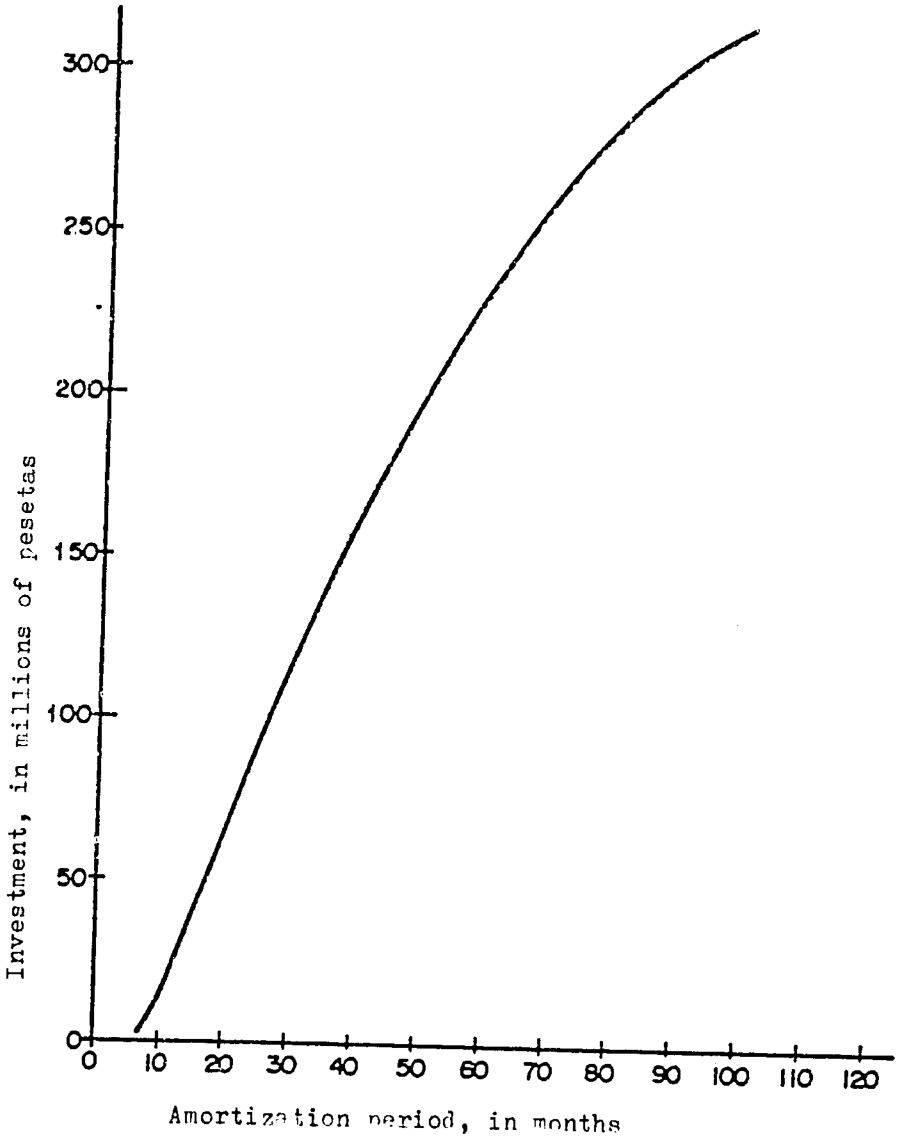
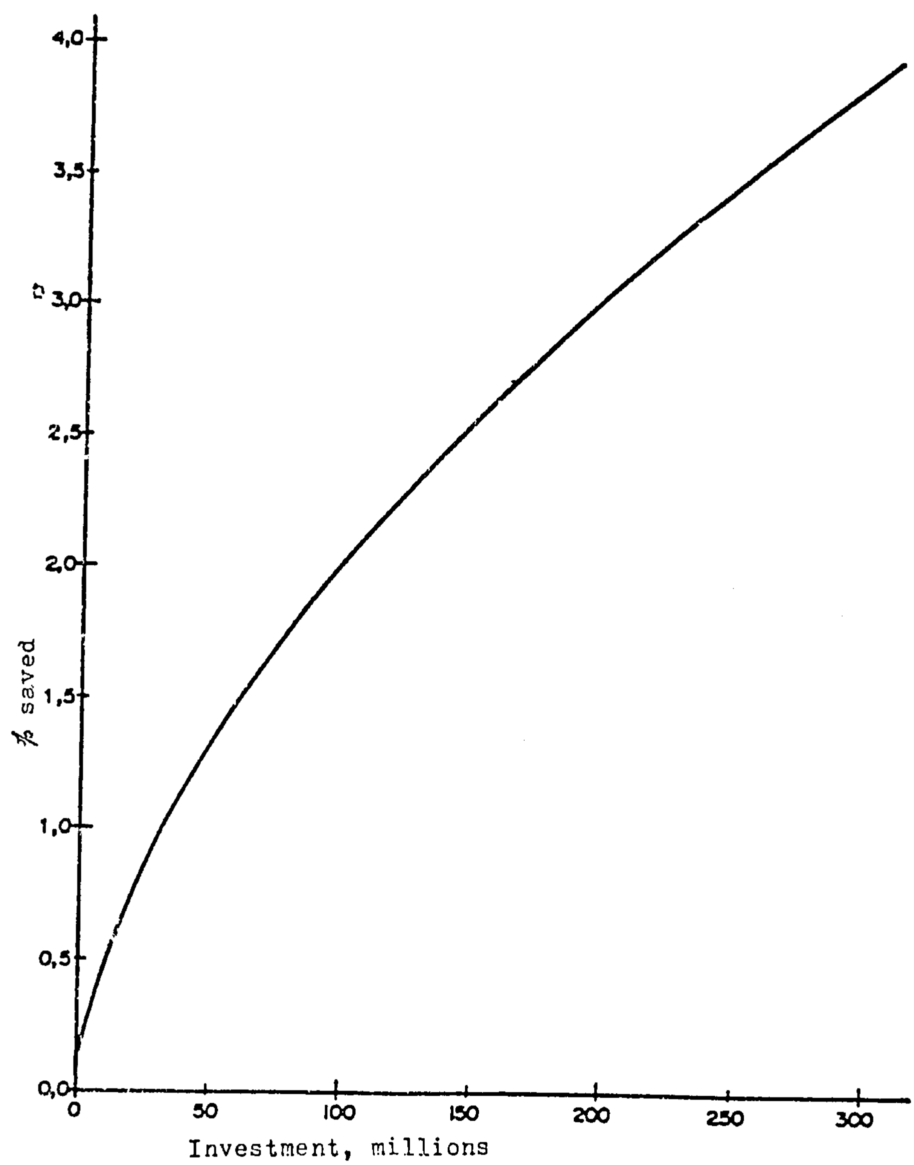


Figure 2.5 Investment/Percentage of savings ratio



Consequently, as the sugar industry works short but very intensive seasons, its energy problem is eclipsed during the working period and must be dealt with during the inter-season period by taking the necessary measures.

Pulp establishes no industrial relationships because it is sold directly to the consumer.

It is worthy of mention that in other counries pulp is consumed in farms belonging to the sugar manufacturer (or associates), thus reducing drying requirements.

3.2 International Trade Balance

Until recently, Spain has had to import sugar. Currently, increased production has made Spain self-sufficient and has allowed for surpluses which will probably be exported to compete with very low international prices that tend to drop in reaction to pressure from new producers. An alternative would be the creation and expansion of new industries that would use sugar, juice, or enriched molasses as raw material.

3.3 Energy Savings Potential

Energy currently represents 6.42% of sugar manufacturing costs, whereas under optimal conditions this figure could be reduced to 4.5%. Thus the potential margin of savings is 1.92% of the sale price. While interesting, this is not comparable to the much wider margins that may be lost or gained by any other production variable.

3.4 Research in this Sector

Apart from the improvements proposed in these industries, others are possible through expansion of existing sugar industry technology and should be experimented with in pilot plants before their large-scale implementation.

Figure 3.1 Present pulp-drying process

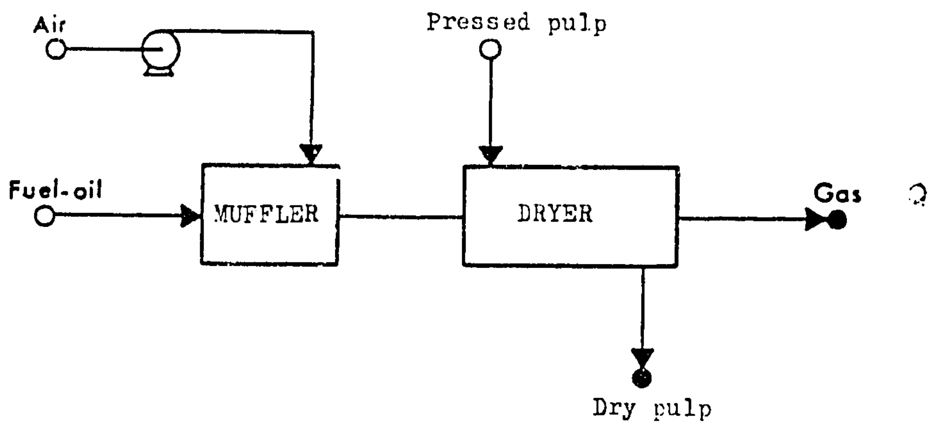
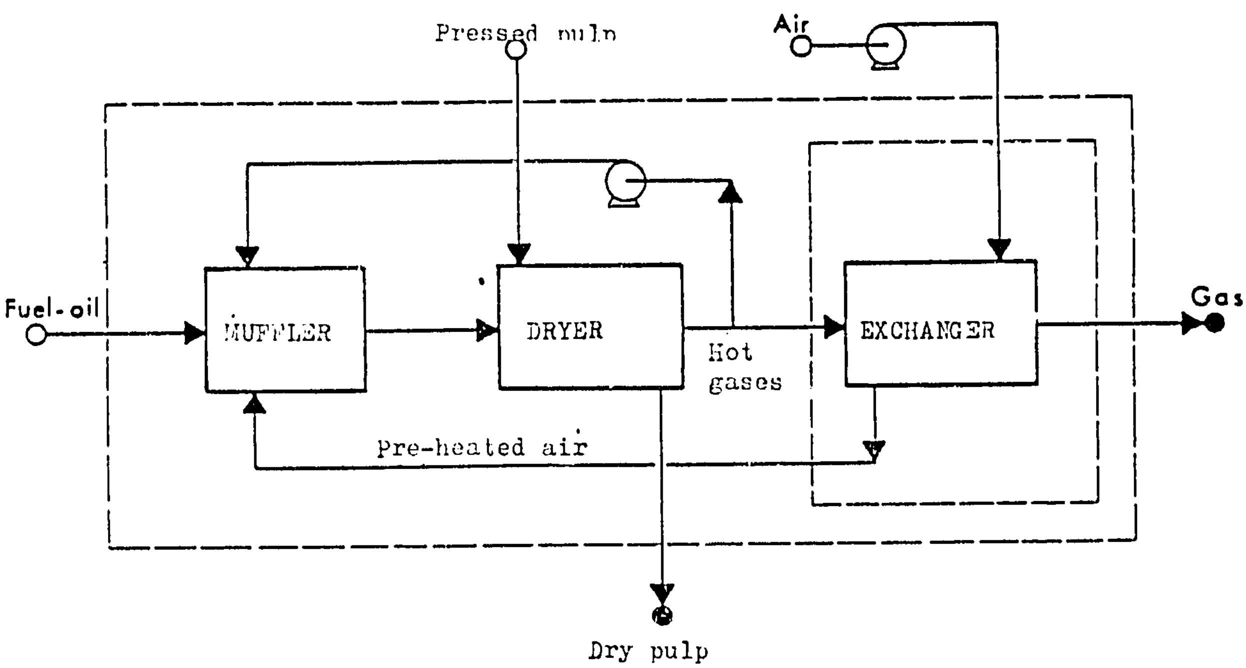


Figure 3.2 Proposed pulp-drying process



3.4.1 Recycling of Dryer Exhaust Gases to the Mixing Chamber, to temper the Combustion Gases

Figure 3.1. shows the present process flowchart for a rotary pulp dryer. The dryer exhaust gases with their high heat content currently go unused.

These gases could theoretically be used in the process itself to pre-heat the combustion air. Another possible solution is to recycle part of the system's effluent gases to the muffler to temper the combustion gases to the dryer intake temperature. As the two solutions are not incompatible, they may be applied simultaneously. Figure 3.2 shows the diagram of the proposed process.

3.4.2 Preconcentration of the Diffusion Juice or Pre-limed Juice

With the heat from the fumes produced in vats, dryer fumes, or other currently unused heat flows, the juice can be preconcentrated to 20 Bx. This should not present any difficulty as this concentration of juice has on some exceptional occasions been obtained and no filtering problems have arisen.

The heat needed for the filtering stage with Brix 20 is much less. The heat saved, with a base Brix of 16 could be as high as 20%.

During evaporation, the savings obtainable with a Brix of 20 are greater, as high as 25% of the heat required at present.

3.4.3 Integration of Boilers and Pulp Dryers

The heat required by the pulp dryers is approximately 40% of that required by the boilers.

To function properly, pulp drying gases must be at a temperature of between 750 and 800°C. This makes the integration of boilers and dryers possible, wherein boiler gases are cooled to 800°C and then passed to the dryers. In this way, some elements such as vaporizing convection beams, economizers, etc., may be eliminated from the boilers.

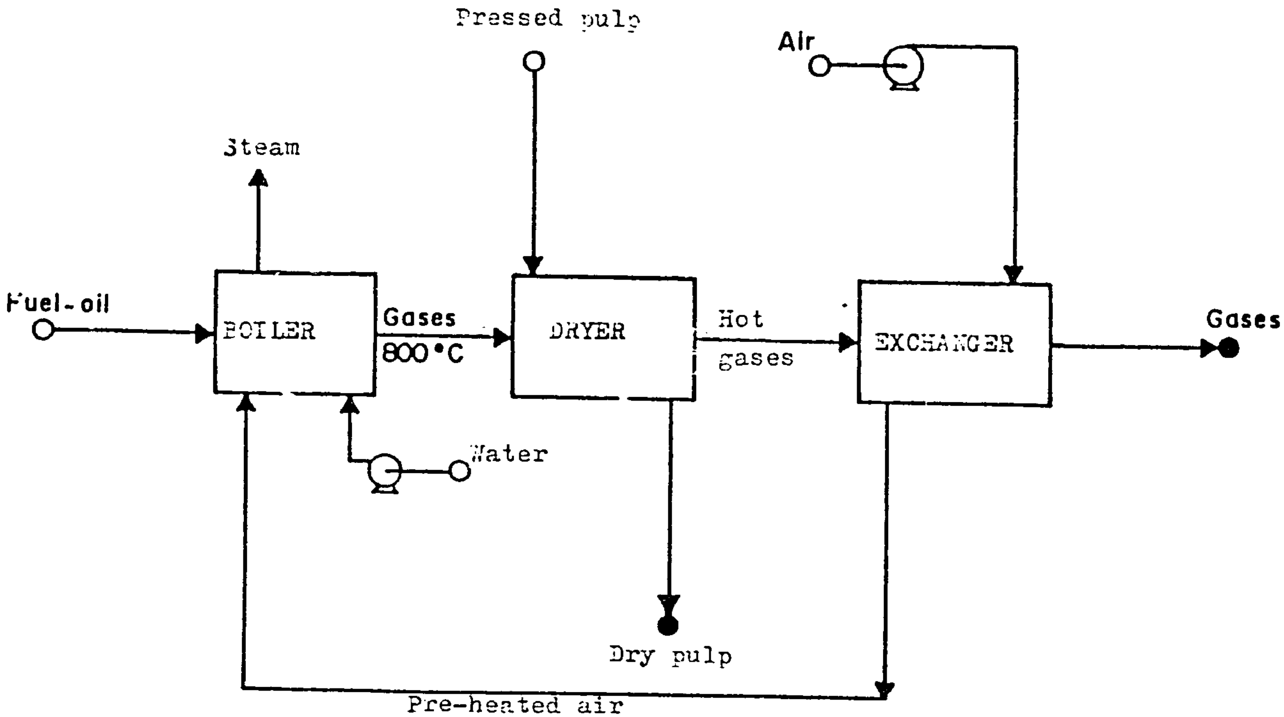


Figure 3.3. Boiler/Dryer Integration Process

The combustion chamber is also eliminated from the dryers, burners are joined, and the fuel-oil network is simplified.

The dryer exhaust gases may be used to pre-heat combustion air.

Figure 3.3 shows the diagram of the proposed process.

3.4.4 Lengthening of the Season

One of the negative factors in the sugar beet industry is the shortness of the season. Various approaches may be studied for lengthening it:

- Diversification of varieties of beet, both early and late types.
- Location of factories in the border area between summer and winter zones.
- Canning of half-concentrated or concentrated juice.
- Canning of beets.
- Drying of beets (Vecchis process).

All of these approaches are of possible interest and should be developed. Regarding the last, the possibility of preserving beets, cleaned and washed in cool (15°C) chambers or in an aseptic (SO_2) atmosphere could be studied.

3.4.5 Other points of interest that may be researched include the following:

- Vertical crystallizers
- Automatic cooking
- Review of the filtering process
- Sizing of motors
- Restructuring of the evaporator system to allow for partial utilisation of the backflow
- Use of centrifuges in pulp drying

3.4.6 Implementation of the Research

In order for all these ideas, and many others not yet compiled, to be put into practice, and for foreign technology to be adapted to the Spanish beet (quite different even when using the same seed), a sugar technology research agency and a semi-industrial pilot/demonstration plant would be quite useful.

Many more improvements are possible. As evidence of the possibilities, there is the 7% savings in the 1976-77 season compared with 1975-76 achieved by merely adopting conventional measures, and the 10% lead that French, Germany and Danish sugar mills have over us even today.

FACTORS WHICH INFLUENCE THE RATIONAL USE OF ENERGY*

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In FY83, the World Bank loaned US$3.4 billion for energy projects which amounted to 26% of the year's total commitments. Each project must be economically and financially viable and the energy to be provided under the project should be efficiently consumed.

As a consequence of carrying out 30 energy assessments (joint UNDP/World Bank Project), and a series of studies on industrial energy conservation in developing countries by the Bank a substantial potential for recovering the efficiency of energy use has been identified. Particularly, it was observed that:

(1) Some LDC's have a higher absolute energy consumption per unit of GDP than developed countries.

(2) The energy consumption per unit of GDP of LDC's is generally growing at a faster rate than in developed countries.

(3) LDC's generally have a higher specific energy consumption per unit of product

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* The views expressed in this paper are not necessarily those of the World Bank.

The absolute energy consumption per unit of GDP for selected countries is shown in Table 1. It is appreciated that the method and accuracy of measuring GDP varies from country to country; however, several observations can be made.

For the example selected, the energy intensities of developed countries are closely grouped (standard deviation, Sx = 0.25); while those of the developing ones are widely spread, (Sx = 0.62). This variation in energy intensities reflects the diversity of economic structures within the LDC's selected.

LDC's are generally moving to higher levels of energy intensities while developing countries are decreasing their energy intensity.

As shown in Table 2 there is considerable diversity within the two groups. Within the developed countries the performance of countries has varied considerably. For example, Japan has reduced intensity by an average of -2.11% (1973/79) while Australia has increased intensity by +2.62% p.a.

Similarly within the LDC's, China (with a high absolute value) has reduced intensity by -0.66% p.a. (75/80) while Nigeria increased energy intensity by +12.89% p.a.

Based on experience gained under the studies made so far it has become apparent that some countries have developed more effective energy management policies and the success of these policies is somewhat reflected in the energy intensity trends of Table 2.

The comprehensive identification of more effective energy policies is an important input for the development of Bank policy and activities. The Bank is aware of the need to better understand the interaction of the various factors which impact on energy efficiency and the development process, so that programs can be prepared and their potential successful application in other LDC's a priori assessed.

Table 1

Energy Intensities of Selected Countries
(T^E PER US$000 of GDP at 1980 prices)

Developed Countries	1975	1980
U.S.A.	0.77	0.70
Canada	0.89	0.95
Italy	0.40	0.37
Japan	0.38	0.35
Germany	0.35	0.33
France	0.30	0.31
$\bar{x}$ (AV) =	0.52	0.50
Sx (SD) =	0.25	0.26
95% CL =	0.78 -0.26	

Table 2

LDC's		
China	2.13	2.06
Mexico	0.42	0.47
Brazil	0.36	0.36
Indonesia	0.36	0.35
Bangladesh	0.20	0.24
Ghana	0.12	0.16
Nigeria	0.06	0.11
Nepal	0.06	0.07
$\bar{x}$ (AV) =	0.44	0.46
Sx (SD) =	0.62	0.59
95% CL =	0.88	

Source: World Bank

Market Factors

To develop an understanding of how energy consumption interacts in the market-place the following need to be considered:

(1) To identify at each of the macro, sectoral and enterprise levels, which policies and measures promote and inhibit energy efficiency and the subsequent impact on GDP. Relevant measures would include energy pricing, energy management legislation, institutional arrangements, audit/technical assistance programs, fiscal and other incentives, promotional/educational programs, special financial assistance and restrictions on the import of foreign technology.

(2) To develop a set of indicators of energy intensity and efficiency which will aid in the examination of appropriate policies and will provide a set of benchmark data against which energy efficiency indicators collected in future work can be measured. These indicators should range from the macro to the enterprise level and across sectors. For example, energy consumption per unit of output, toe/$1000 of GDP or MJ/tonne of product; MJ/tonne of product; MJ/tonne -km for freight transport and MJ/m^2 for buildings.

(3) To determine why and how policies work, together with such indications as are possible as to their impact on energy intensity and efficient energy utilization.

(4) To identify the relative importance of management both at government and consumer levels, as it relates to the various groups in the supply/demand chain.

(5) To identify the importance of technology transfer mechanisms and the most effective way to facilitate the transfer of energy efficiency technology.

In trying to understand the energy consumption process, many practical problems are encountered; some examples are as follows:

(1) Lack of data on energy use. Although this problem is by now almost solved in developed countries, many LDC's have not yet developed comprehensive energy data gathering and reporting systems.

(2) Accuracy of indicators. Variations in methodology and computing techniques can cause significant variations in measured variables, making intra- and inter-country comparisons impossible.

(3) Lack of standardization in both collection units and sector definitions makes inter-country comparisons a very difficult task.

Strategies for Improving Energy Efficiency

Notwithstanding the problems enountered above, the Bank's experience indicates that the success of some industrialized nations in improving energy efficiency both in terms of reducing the energy input per unit of output and in reducing the cost of energy inputs through substitution for more economical forms of energy, suggests that there are lessons from their experience possible worthy of transfer to the developing world. Efforts to date in some LDCs are yielding some worthwhile results covering both energy efficiency and transformation of the energy supply mix.

Obstacles to Rational Energy Use

Experience so far has also shown that there are barriers holding back the rapid adoption of energy efficiency efforts in some LDC's.

These barriers may be categorized as follows:

(i) Lack of awareness: government, officials, managers, technicians, drivers, workers, householders, farmers, etc. are frequently unaware of the importance of/or opportunities for energy conservation, or that energy efficiency may be significantly affected by their own decisions or behaviour and have a significant impact on their personal economic well-being or that of the institutions or enterprises for which they work; people may simply be unaware of the absolute and relative cost of energy in their personal or occupational activities or within their particular enterprise, and the impact that energy savings could have on the profitability of the enterprise;

(ii) Attitudinal: official, professional and private individuals, from government officials to householders, may not feel that energy efficient behaviour or decisions deserve significant priority in their business affairs or private lives; they may not see it as attractive as increasing energy supplies or pursuing other strategies; they may also perceive that the benefits of energy efficient measures may not be confidently relied upon to exceed their cost sufficiently; indeed the lack of favorable attitudes towards energy savings may just be part of an overall lack of cost consciousness or profit orientation;

(iii) Institutional: governments may have no departments or other institutional entities with clear responsibility for designing and implementing energy efficiency policies or programmes; there may be little legislative or regulatory framework addressing energy management responsibilities; and capable profit-oriented cost conscious managers, technicians and operators may be in short supply;

(iv) Technical: the technical know-how may be inadequate within governments and enterprises or on the part of private individuals to take on the task of designing and implementing energy conservation measures or investments; appropriate technology, goods or services may not be available to assist individuals and enterprises to improve their energy efficiency;

(v) Economic/Market: national economies and markets within them may not respond rationally or quickly to price and other stimuli for some of the reasons just mentoned or because certain distortions exist between the price of energy charged to consumers versus its economic opportunity cost, or because tariffs, taxes, interest rates or other economic and financial policy variables restrict the availability of energy efficient goods or services, or of more efficient energy alternatives; conversely, such policy instruments may not be sufficient to induce individuals or enterprises to behave in the energy efficiency interests of the economy; also, the impact of higher energy prices may be diluted in an economy where the consumers of energy can easily pass on the cost through increased prices for their goods or services, either through lack of competition or because the price of energy-intensive goods and services are regulated on a primarily cost-plus basis;

(vi) Financial: individuals, enterprises or governments may have insufficient financial resources at an attractive cost to induce them to incur costs or make investments that will improve energy efficiency, or, they may only have sufficient funds to devote to other purposes e.g. expansion of production, to which they would then assign higher priority.

Energy management strategies need to be designed to address these obstacles and targeted to the relevant energy-consuming sectors of the economy.

Demand Management Strategies

Experience has shown that a comprehensive set of energy demand management strategies which will induce rational decision making on energy efficiency includes some combination of the following:

(i) Legislative Framework

Virtually all the industrialized countries have some form of legislation dealing with energy conservation. Some developing countries have also enacted such legislation. These laws vary in their scope, and may designate governmental organizational responsibilities and powers for various conservation policies and programs; may require certain practices (audits, energy managers, etc.) on the part of enterprises, and may set the framework for regulatory measures to be developed by various agencies or levels of Governments that deal with particular sectors of economy. Such legislation is one important sign of a government's commitment to improving energy efficiency.

(ii) Institutional Framework

Most industrialized countries have for some time had officially established agencies or departments with the specific responsibility for national energy conservation policies and programs. These are normally an organizational arm of the Ministry or Department of Energy but are sometimes in the Ministry or Department of Industry. Few LDC Governments have established such functions: some have done so in only a token way. Normally, these agencies develop and administer various informational/promotional programs aimed at the various energy/consuming sectors, and sometimes oversee sizeable budgets for the support of industrial energy audit programs, technical assistance, home insulation and research and development. A few countries, e.g. Japan, have also established governmental/industrially supported Energy Conservation Centers providing technical assistance to energy users, but many countries have left this more intensive activity to private consulting firms or other types of private institutions. Some countries have established energy audit or technical assistance arms within or linked to energy supply enterprises (utilities, petroleum companies).

(iii) Rational Pricing Policies

It is widely believed that the pricing of the various forms of energy should broadly be based on opportunity costs (usually border prices for internationally traded forms of energy) to achieve rational patterns of supply and consumption of the energy options available to those countries. Most LDC governments exercise some degree of control over energy pricing, either directly or through various forms of taxation, but many are prone to subsidize directly or indirectly and thereby distort supply and consumption patterns. Of nearly thirty countries covered so far by the Energy Assessment Program, less than a third follow across the board opportunity cost pricing, over a third have a "mixed" approach, and about a third have severe price distortions in nearly every form of energy. In the short term, many energy users, even in the more market-oriented LDC's, have not responded to price changes and differentials as rationally or quickly as in less regulated, more modern free-market economies. Some of the barriers to this response have already been outlined above, and some of the non-price measures to counteract this phenomenon are discussed in the following paragraphs.

There are many examples where energy intensity is excessive due to under-pricing of energy, or where steps towards fuel substitution are not taken due to distortions in fuel pricing structures. Such distortions are not so common for industrial petroleum fuels or gasoline but are widespread for power, domestic coal, kerosene and diesel fuel, for a variety fo political and economic reasons. The full impact of rational energy pricing cannot be realized in some countries in the short term, however, until the "pass-through" effects to energy-intensive goods or services are curtailed by lesser regulation and greater competitive pressures, and until energy intensive economies can be restructured to more efficient levels so as to minimize the economic/financial disruption that dramatic energy price increases would produce.

(iv) Promotional/Education Programs

The lack of awareness and attitudinal bariers to improved energy efficiency discussed above have been the target of a variety of promotional and educational programs in virtually all industrialized countries, and in an increasing number of LDC's. These programs are implemented by Government agencies, energy conservation centers and institutes, consultants and energy supply enterprises. They are thus in both the public and private sectors. A variety of media are used and in many countries special programs are targeted to schools and specific industrial or commercial groups. The impact of such programs is limited however, without more intensive complementary efforts involving specialized energy audits, training and technical/managerial assistance.

(v) Audit, Technical Assistance and Training Programs

Many countries have introduced or promoted the development of national programs and capabilities to provide industrial and commercial enterprises, farmers and householders witn a variety of technical services to analyze and improve their enrgy consumption and management. Varying mechanisms are used for providing these services through government agencies, commercial/industrial trade associations, private consultants, academic/research institutions and energy supply enterprises. Such programs can be truly effective, whether in industrial plants, transportation enterprises, commercial buildings or residences and are an essential component of any national energy efficiency program. Some countries have legislation or regulations that require energy audits for certain enterprises and some subsidize their cost.

(vi) Economic, Fiscal and Trade Policies

Apart from the pricing, legislative and institutional policies discussed above, there are a variety of other government policies that can influence a nation's energy efficiency efforts. These may include tariff and non-tariff policies that encourage or restrict the investment in, import or domestic production of a variety of energy conserving, consuming or converting equipment, technology or know-how. Such policies may greatly influence whether a nation has available and makes use of more energy efficient industrial plant and equipment, motor vehicles and other transport equipment, energy control systems, solar equipment, stoves, electric appliances, energy efficient building materials, etc. Regulatory policy may also induce local manufacturers to improve and promote the energy efficiency of their products as has been so successfully done for automobiles and appliances in some industrialized countries.

(vii) Capital Allocation/Financial Assistance

With increased pressures on capital availabiity and interest rates still high in real terms, priorities for investment in energy supply and demand option need even greater scrutiny. Experience has shown that greater recognition still needs to be given by governments and enterprises that investment in energy efficiency improvements can have high economic and financial returns and the cost of a barrel of oil, ton of coal or kilowatt hour saved is often much less than the cost of incremental supply. Nevertheless, governments and businesses have a predisposition to GDP-increasing, revenue-earning and supply oriented investments, and cost-saving measures often need some extra incentive before they are taken. One way of doing this is to allocate special funds for such investments, sometimes at concessional interest rates. Brazil had done this with some success, and tne Bank has supported energy conservation financing by development of finance institutions.

Such funds can be earmarked not only for energy-saving or substitution investments by energy consumers, but also for productive investment, R&D and for more efficient energy consuming or converting equipment (boilers, generators, solar heaters, etc.).

(viii) Energy Information Systems

The Bank's experience has shown that very few LDC's have adequate information on the consumption of energy. Most have broad statistics by sector (industry, transport, gasoline, coal, power, etc.), although such sectoral data is often not rigorously categorized, with "overlaps" between sectors (for example, transport energy consumption within the industrial and agricultural sectors, residential energy within the agricultural sector, etc.). Hardly any countries have data by sub-sector (e.g. iron and steel, fertilizers, road transport, residential v comercial buildings, etc.) by type of energy and data on the consumption of fuelwood and other traditional fuels are extremely rough, even though in many countries such fuels account for over half of total energy consumption. A growing number of countries are receiving assistance for/or preparing on their own detailed energy balances to provide information bases for energy planning, including demand management. Also, energy audit programs, at least in the larger industrial plants, are beginning to build up energy consumption information at the enterprise level. There is a long way to go, however, to get to the point where national energy information systems are adequate for effective monitoring of energy use patterns, so that demand management and supply strategies can be developed and revised in a dynamic and more effective way, and their impact assessed.

Priorities and Options for Energy Efficiency Improvement in the Key Consuming Sectors

Most of the strategies discussed above are relevant, in varying combinations, to improving energy efficiency in each of the key consuming sectors: industry, transport, agriculture, residential and commercial.

Potential Savings and Related Investments and Technical Assistance Needs

The potential for substantial energy savings in the LDC's is clear, and the costs of bringing these about in the short-term are such that net economic benefits will be extremely high. Where investment is required, particularly in industry, investment returns are attractive. If the requisite policies, programs, as well as financial, managerial and technical assistance could be put in place during the 1980's, LDC energy consumption could be at least 20% less in 1990 than it would be if recent trends are extrapolated. Savings by the year 2000 could exceed 30%. On the perhaps more realistic assumption that policy changes and the allocation of financial and human resources will continue to be hampered by some of the obstacles discussed earlier, savings between 1980 and 1990 might be closer to 10% i.e. energy demand growth could be reduced by about 1% per annum for a given rate and pattern of economic growth.

The investment requirements to modify existing industrial plants to achieve some of these savings is enormous, and a considerable proportion of the potential savings can be achieved at little cost. Investment requirements for improved energy efficiency in other sectors are mainly not susceptible to being labelled energy efficiency or conservation investments i.e. investment in more efficient transport vehicles, power distribution systems, agricultural equipment and more efficient buildings clearly serve other needs beyond energy efficiency. Retrofitting in the transport, power, agriculture and buildings sectors clearly has identifiable costs but insufficient information is available to make meaningful estimates at this point and much of the cost would be more appropriately categorized as operating rather than capital cost.

Also of relevance, particularly in the short-term, are the resources required for technical/managerial assistance to design and implement energy efficiency policy, institutional and program changes in the LDC's.

The Bank's Role: Past, Present and Future

The World Bank has been increasing its activities in the energy conservation/efficiency area for the last two to three years, consistent with its increasingly active role in the energy and industrial sectors. Bank lending for energy has increased and the number of its lending operations and studies related to energy efficiency has grown. Its principal activities include the following:

(i) The UNDP/World Bank Energy Assessment Program has assessments well advanced in 30 of over 60 planned countries, with energy demand management and conservation identified as key issues in nearly every assessment.

(ii) A number of structural adjustment loans already made and in preparation directly address energy conservation e.g. energy audits for major consumers, energy pricing.

(iii) A number of loans have been made (about 13) and are in preparation (about 20) for the industrial sector, involving retrofitting/rehabilitation investments in existing plants, e.g. refineries, steel, cement, fertilizers as well as technical assistance components for energy audits, establishment of energy conservation centers, etc.; also some loans are directed to development finance institutions which relend the proceeds for investments in energy conservation equipment.

(iv) A number of loans are being made and prepared to address improvement in power distribution systems, improve power system management and power tariff issues.

(v) A number of components of technical assistance of energy sector projects (petroleum, power) are assisting countries to carry out energy audits and other conservation related studies.

(vi) A number of forestry projects have included components to assist in the development of more efficient woodstoves.

(vii) A number of urban traffic management projects are designed to alleviate congestion and thereby reduce fuel consumption.

(viii) A number of country-specific sector studies on energy conservation are underway, particularly in the industrial and transport sectors.

(ix) A number of sector-specific studies are being done e.g. in steel, cement, fertilizers, oil refineries and transport.

(x) A whole range of energy sub-sector loans for petroleum, power, coal and industry have addressed energy pricing issues.

(xi) A research project is being planned to investigate the impact of various conservation policy options.

Much has been learned from the Bank's operations, sector and economic work to date but there is still much more to be achieved and it is expected that activities will become even more vigorous in the future, including a continuation of applied research, sectors, subsector studies, lending, increased policy dialogue and technical assistance directed at improving the management of energy efficiency in the developing countries. All of this work will continue to be properly and timely coordinated with substantial planned operations dealing with expansion, modification and improvement of the energy supply in less developed countries

POLICIES FOR PLANNING AND IMPLEMENTING RATIONAL USE OF ENERGY

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INTRODUCTION

This presentation seeks to assess the Brazilian energy policy of recent years, with emphasis on some aspects of policy planning and implementation in the area of rational use of energy in industry.

It is worthwhile to quote a top official from the energy planning sector: "Brazilian energy policy-making is much like the work of a fireman, where today's fire is put out, without knowing if, when, or where new fires will break out."

In other words, the approach to difficult energy problems and their various interrelationships and dependencies has been made, in our opinion, using a very risky information base and without the aid of harmonious actions by all the parties involved; instead, action has often been taken in authoritarian fashions and then continuously reformulated, thus provoking uneasiness, resistance and passive postures.

To back up these assertions, we can discuss some features and steps undertaken in recent years for energy policy in the industrial sector:

a) The Brazilian Energy Model (MEB) itself, published in 1979, contains a methodological/conceptual error since it sets goals for energy supply without considering, in some cases, well-known difficulties. The mistake lies in the fact that these goals established bases for action by several governmental and industrial agencies and caused distortions. These can best be explained by analyzing the goals for national coal development. According to a press statement by a government official (as published in the newspaper "Gazeta Mercantil-26/02/83), the original annual production goal of 23.3 million tons was reduced, in 1982, to 11.6 million tons: at the beginning of 1983 it was reduced again, to 9.5 million tons; and another reduction is anticipated for this year. The official also stated that the coal stocks total some 2.9 million tons, but should reach 5 million tons at the end of 1983, with the latter amount being close to 1982 consumption.

b) The National Energy Inventory (BEN) ceased to be merely a collection of statistics in 1981, when, using the OLADE methodology,a time series of energy balances was presented for 1976-1980.

c) Since 1979, about 2500 companies have been sending information to the National Petroleum Council (CNP) each year, on the use of their main energy inputs; but this information is processed quite slowly and the 1981 data are still unpublished.

d) The 10% in overall industrial oil supplies (using quotas), in 1980, ended up sanctioning those who had already worked out some sort of energy conservation program while discouraging the use of new conservation measures due to the fear of further cutbacks. In 1981 the attempt to work out selective oil supply reductions in industry stumbled on technical difficulties with the appraisal of information contained in forms incorrectly or insufficiently completed, and difficulties with assessment criteria for industrial conservation potential, along with a slowdown of economic activity. The fact that fuel oil was no longer the determining factor in the amount of imported oil reduced the pressure it exerted on industrial energy policy.

e) Pricing and subsidy policies adopted in recent years, as related to industrial energy consumption, have often been unintelligible and changeable, or else have squandered meager resources.

The case of Brazilian coal is noteworthy, because not only did the government make improvements it the harbor, roads and warehouse systems, but it also provided subsidies equal to 50 or 55% of the final prices for coal sold during the 1979-1983 period. Nowadays, these subsidies are no longer justifiable , since the Mcal prices for coal and oil are Cr$2.58 and Cr$5.87, respectively (i.e., the latter is 146% higher than the figure for coal).

Another interesting point is the fact that a special dollar exists for the oil bill; on April 11,1983 it was worth Cr$293.43, as opposed to the offcial dollar worth Cr$426.60. This difference is covered by the CNP, which charges for it through one component (item A) of the price for oil derivatives. The method for defining tariffs for oil derivatives and criteria used in their application have never been clarified, and there are arguments among specialists over whether or not subsidies should exist.

f) In 1980 and 1981 estimates indicated that by 1985 there would be a shortage of electricity, and this fueled the pressure to build new electric power plants. However, in 1982 this sector showed available electricity; and today we can estimate stable power available in Sao Paulo as around 2000 MW, and as 6000 MW for 1986. These are important values if we consider the 39,000 MW already onstream and the 12,000 MW from Itaipu which are still not operating. All this has cerainly contributed to the push for reduced rates (with programs such as non-guaranteed energy, wherein electricity sales contracts are not for more than 600 hours/year, valid up to 1986, with costs equal to about 25% of normal energy costs; as well as seasonal energy costs about 10% below normal costs), but it has also triggered strong pressure for substitution of oil derivativies by electricity. Nevertheless, a concentrated expansion of activities has arisen among thermoelectric outfitters, without medium- or long-term planning.

g) In the cement agreement, a charter of intention–signed in 1979 between cement industries and the Federal Government and geared to the conservation of energy and the subtitution of oil derivatives– a zero fuel oil consumption goal was adopted; but replacement by national coal made no sense, due to the coal-ash index (-30%) and to the distances involved for industries located above parallel 20, since the Brazilian coal mines are situated in the southern states. This ideal also overlooked the possibility of alternative, renewable sources of regional energy such as charcoal, babassu rind, rice husks, etc. The intermediate goals established by the agreement in terms of fuel oil substitution by coal proved unrealistic, since by the end of 1982 less than 40% of the proposed goal (use of 4,280,000 tons/year) had been attained.

I should like to stress that I am not defending industry unconditionally , since the 10% cut in oil supplies did not force any of them to close down or to reduce production; this shows that industry had a savings potential to be tapped in the short term. It also confirms the findings of a paper done on the large oil consumers of the state of Sao Paulo, which concluded that in 15 industries alone there was a potential for reducing national fuel oil consumption by about 2% (-200,000 tons/ year).

I should also like to point out the fact that these aspects do not avoid some very sound energy policy measures such as the signing of agreements, the CONSERVE program, the creation of the National Energy Comittee and its Energy Mobilization Plan.

Thus, in this introduction I have not attempted to provide a full analysis but rather to call attention to some aspects of energy structures, sources, and mistakes within Brazilian industrial energy policy, especially those aspects dealing with how policy was conceived, defined and implemented.

A worthwhile example to cite is a government paper at the end of 1982, which stated that after its publication all industries consuming fuel oil for thermal purposes would have 60 days to replace it by another source of energy. When it became clear that this kind of consumption was only about 1% of the national diesel consumption, and that it would involve hundreds of small users who would get around all kinds of control, by purchasing diesel oil straight from the gas stations, techicians from the IPT and representatives from the FIESP - (Federation of Industries of the State of São Paulo) worked out an alternative mechanism, wich was finally acepted and which can be summarized as follows:

- only those who consume more than 50 m^3/year of diesel oil and are responsible for more than 90% of the consumption, would be affected by the mandate;

- for the other cases, the companies would send to the CNP (National Petroleum Council) their diesel oil substitution plans and the CNP would lift them in any of the following cases:

I- substitution by gaseous fuel;
II- substitution by liquid fuel;
III- substitution by solid fuel;
IV- substitution by thermoelectric processes;
V- special cases.

Thus, a sound proposal was made and it was endorsed by the interested sectors. Tecnically, it was perfect and trouble would not arise with its application.

This brief introduction also serves as background for the following explanation about two broad programs where work is currently underway: CONSERVE, of national scope; and the IPT/CNP program, which would be applied in the State - both seeking the most rational use of energy in industry.

2. THE CONSERVE PROGRAM

2.1 Introduction

Today the CONSERVE plays an important role in the Brazilian energy conservation and substitution program of the industrial sector.

The industrial sector was reponsible for about 75% of the fuel oil, 8% of the diesel, 55% of the electricity and more than 85% of all coal and charcoal consumed in the country in 1981. During these years, industrial energy consumption was 38.8% of total consumption, when the imported energy input was 30%. Thus, the goals proposed for CONSERVE in 1981, when it was created, are still valid:

- to encourage the reduction in all kinds of industrial energy consumption;
- to further the substitution of imported energy used in industry by Brazilian alternatives;

- to stimulate the development of industrial processes and products which could bring about greater energy efficiency;

- to provide financial resources for programs, projects and studies on imported energy substitution and energy consumption reduction in industrial units.

The CONSERVE can be seen as an extension and enlargement of the MIC (Ministry of Industry and Commerce) activites, which as of 1979, began to establish agreements with the cement, iron and steel, cellulose and paper industries.

This expansion has had consequences in terms of research and information dissemination, articulation in terms of research institutes, energy diagnoses and the allocation of financial resources to industry for the establishment of projects leading to a more rational use of energy.

2.2. Operation

The following agencies take part in directing the CONSERVE:

CDI - the Industrial Development Council, in charge of giving administrative aid to the program.

STI - the Industrial Technology Secretariat, in charge of giving technical aid in projects related to the conservation and substitution of energy.

BNDES - the National Bank for Social and Economic Development, as a financial agent and distributor of funds to regional development banks (BD).

CONSIDER - Iron and Steel and Non-Ferrous Council, as a sectorial participation agency.

They are joined in CIPAI, the Chamber of Industrial Planning Integration, which, apart from generally overseeing and conducting the program, takes the results to SEPLAN, the Planning Secretariat of the Presidency of the Republic, which allocates new resources.

The credit approval procedure is as follows:

1) The industry presents to the BNDES or to the regional development bank (BD) a preliminary proposal or letter of consultation.

2) If an approach is made to the BNDES, it may call on the research institutes to make an energy diagnosis and to identify, in order of preference, a group of proposals aimed at energy conservation and substitution and possible to carry out in this industry. Table I presents the order of priorities for the ceramics industry.

3) In the event that a BD is approached, such an analysis is mandatory.

4) Based on this diagnostic, and an analysis of the company's economic/financial situation, the preliminary proposal is or is not approved by the BNDES. When there is a positive response, a definite proposal must be made by the industry; and if it is approved, this means that resources will be allocated and the proposed projects can be implemented.

5) Whenever possible, upon a request to the CDI, fiscal incentives can be obtained (IPI credit for national equipment, depreciation accelerated from 10 to 5 years or 3 years, etc).

6) After project implementation, the research institute is in charge of submitting a final assessment in order to evaluate if the specified conditions for equipment, processes, etc., have been complied with.

2.3. Criteria and Standards for Granting Loans

Financial aid is granted to industrial or agroindustrial firms with a majority of national capital stock, considering:

- the best technological and economic uses of energy inputs
- the applicant's technical, financial and economic business capability
- the smallest ratio between investment and energy input reduction or substitution, especially of imported energy.
- the lowest cost of adapting the infrastructure and external economics and for making the energy flow adequate in the case of fuel oil substitution

The following aspects are also considered:

- the project's contribution to the balance of trade
- its contribution to increased job opportunities; and
- its contribution to improved ecology in the area involved.

The CONSERVE standards also suggest that financial agents:

- emphasize financial aid to small and medium-sized companies in order to help as many as possible;
- stimulate the demand for capital goods alloted to the production and use of alternative energy inputs;
- foster the transfer and development of industrial technology in order to increase nationalization indexes for equipment and indus-

trial processes;

- stress programs, projects and studies which can aid energy input regionalization;

- stimulate the adoption of environmental conservation measures; and

- contribute to attainment of CONSERVE goals and to the transformation of the industrial sector's energy demand.

2.4 Loan Conditions

The major conditions could be described as follows:

- CONSERVE financial aid is granted only for financing fixed assets, aimed at changing the production units already in operation;

- interest rates of 5% annually;

- monetary indexes according to the ORTN's (variations in Readjustable Debts of the National Treasury)

- funding limit of 80% of the investment value

- three-year grace periods

- loan maturity up to 8 years after disbursement.

2.5 Technological Training Actions

In order to strengthen technological training activities and the efficiency of the program, the STI (Industrial Technology Secretariat) created a program known as CONSERVE/TECHNOLOGY, which is developed parallelly and in close collaboration with CONSERVE, and which has available 3% of the resources allocated to the CONSERVE program. These resources are handled directly by the STI.

The CONSERVE/TECHNOLOGY program has three different lines of projects:

- Technological Extension: This involves a network among technological institutions and 100 graduate technicians in different areas of the country, who are called upon to provide free energy analyses. Through these, industries learn about their possibilities for energy conservation and substitution indexes, etc.; and in some cases they are helped in formulating a letter of consultation to the BNDES or BD. To aid institutions with little previous experience in conservation, a handbook was prepared on how to elaborate such analyses; an intensive program was set up in the IPT (the Technological Research Institute of the State of Sao Paulo); and visits were exchanged by technicians among the institutions.

- Experimental Developments: Here, agencies, technological institutes or industries are provided with aid geared to the development of highly-efficient energy equipment, at the laboratory and prototype levels.

- Information and Dissemination: In this area, technical information about energy conservation is gathered, processed and disseminated, thus allowing the transfer of practical results, procedures, and standards for testing and calculations, etc., to technical and industrial sectors.

2.6 Resource Allocation and Results

The resources of the Energy Mobilization Program (EMP) that are allocated to the CONSERVE, as well as the results obtained, the approved letters of consultation, the approved projects, the financial demands and expenditures made during 1981 and 1982, are summarized in Table I.

All in all, the oil economy for the 55 projects already approved corresponds to 1.2 million TOE per year, which is about 2% of the oil consumed in 1981.

As for the CONSERVE/TECHNOLOGY technical aid activities, the principal results are as follows:

- the elaboration of 67 energy analyses for 1982;
- the identification of the possibility of economizing 162,000 TOE per year or 10 billion cruzeiros (December 1982);
- the investments necessary to implement this potential in the 67 cases, amounting to 4.3 billion cruzeiros;
- every one U.S. dollar invested in a diagnosis permits an annual economy of about U.S. $63 ;
- the cost of the diagnosis corresponds to about 3.7% of the investment needed to implement the advice identified through the diagnoses;
- execution of 9 of the 22 projects underway in the area of information and dissemination;
- conduction of 12 experimental development projects;
- Figures I and II show the resource allocation for CONSERVE/TECHNOLOGY;
- periodic meetings with STI, CDI, BNDES and research institute representatives to appraise and monitor the CONSERVE, in an attempt to find ways to overcome difficulties and bring about closer technical ties among the members.

2.7 Conclusions

a) In spite of the clear advice to aid small and medium-sized industrial firms, most of the projects approved by CONSERVE involve large industries, even though most of the diagnoses refer to medium-sized and large industries. Some agencies are making efforts to change this situation; they are looking for bottlenecks in the process, from the preliminary presentation up through elaboration of the energy diagnosis and resource allocation.

b) To the complaint about slow bureaucratic procedures must be added the economic and financial difficulties provoked by the economic recession being suffered by our country, which, together, with present uncertainties, explains why many of the allocated resources were not used (21 billion cruzeiros against 15.3 billion actually disbursed by the BNDES in 1981-82).

c) Despite these distortions, it seems that the association of different entities (technological development agencies, financing agencies, research institutes and industries), trying to act in a coordinated way towards a common goal, is one positive aspect of Brazilian energy policy.

3. AID TO THE INDUSTRIAL PROGRAM OF ENERGY CONSERVATION

The program of aid to industrial energy conservation in the State of Sao Paulo is aimed at better efficiency standards and more rational use of energy inputs. It assumes throughout that interaction among energy control and development agencies, industries and training and research institutes is both possible and necessary.

This program, which from the start has been aided by the federation of industries and industrial technicians, began in mid-1982. It can count on resources from the Energy Mobilization Program (EMP), authorized by the Energy Committee of the Planning Secretariat (SEPLAN) of the Presidency of the Republic. These resources are then distributed by Projects and Studies Financing (FINEP).

The program, which is to be implemented by the Technological Research Institute of the state of Sao Paulo (IPT), can also count on the National Industrial Education Service (SENAI) and cooperation from the National Petroleum Council (CNP).

With the aid of all of these agencies, institutions and industrial federations, efforts have been made to assure that the contribution becomes the driving force of the proposed activities.

The program, which will last for three years, has a full-time staff of 1 manager, 4 coordinators, 18 researchers, 3 technicians and 3 administrative technicians.

3.1 Program Structure

In order to reach the goals set, various kinds of actions have been presented within the global project - through specific, differentiated approaches, so that the program can be divided into the following subprograms:

- I : Assistance and follow-up for the 90 major consumers
- II : Aid to the industrial energy conservation program
- III : Sectoral energy conservation handbooks
- IV : Training of thermal equipment operators.

The need to approach the industrial energy picture from different standpoints is due mainly to the features of the national industrial consumption distribution profile, as shown in the ABC curve of Figure III (total fuel oil consumption, percentage-wise, as opposed to the number of industrial consumer units).

We can see that 65% of the national fuel oil consumption is concentrated among only 200 consumers, and about 90 of these are in the State of Sao Paulo. Since this number is rather small, it is feasible and justifiable to follow each one of them through Subprogram I.

As for the Group B enterprises, where about 2,500 industrial units consume more than 500 tons of fuel oil per year, or 30% of the total consumption of this derivative, they have been approached through samples with surveys and diagnoses in typical installations in the different industrial sectors, according to what is planned under Subprogram II.

Together with the systems to contact the industries of Sao Paulo, complementary activities have been developed so as to make this program broader and more in-depth. Thus, Subprogram III intends to publish, over the next three years, more than five Energy Conservation Handbooks for the industrial sectors still untouched by the IPT.

Finally, Subprogram IV aims at creating human resources through a three-year training program for about 6,000 operators and managers, whose direct action in the handling and use of energy will be extremely important in industrial output.

3.2 Assistance to the 90 Major Consumers

In this subprogram, the activities involve visits by IPT technicians to the industries under consideration. So. by means of the interaction between industrial technicians and the IPT, a system will be developed to follow up on energy input yield.

The technical level achieved by many of the industries' Energy Conservation Committees (CICE's), along with IPT experience in this area, show that highly positive results can be attained through such cooperation.

These surveys reach the following basic targets:

- Identification or confirmation of possibilities for reducing consumption by means of increased efficiency or the introduction of alternative sources;

- Observation of limitations intrinsic to each process or industrial unit capable of involving non-feasible technical or economic aspects in a certain project, to reduce energy consumption;

- Systematization of the information obtained, permitting the establishment of objectives adequate for industrial realities and thus scrupulously directing energy policy;

- Studies to be undertaken by the IPT as a basis for the loan process and aimed at improving resource application in projects to reduce consumption;

- Contributions towards the expansion of consultation and project activities, through the proposal of alternatives that will need to be developed or detailed by industrial or engineering projects and consulting firms.

3.3 Technological Support to Sao Paulo Industries Consuming More than 500 Tons Per Year

This subprogram is geared to detailed energy diagnoses in typical installations in the State of Sao Paulo, to be chosen by sampling in the different industrial sectors, in order to examine units whose consumption is over 500 tons per year, aside from those included under the foregoing program.

Developed in this way, with the support of duly-outfitted vehicles, these diagnoses have the following roles:

- They serve as a means for disseminating technical information on the technical and economic feasibility of energy conservation measures, focusing on the peculiarities of each sector or subsector. This material is being distributed through the different media, such as newsletters, specialized magazines, syndicates and technical association papers, symposiums, etc.

- They can serve as criteria for the assessment of projects and programs and for loans from government agencies.

- They can be used as reference materials for other research institutes and consulting bureaus involved in energy conservation programs and also as a stimulus to the companies to implement or broaden their own programs, through their committees or with aid from consulting firms specializing in this area.

3.4 Preparation of Sectoral Handbooks On Energy Conservation

This subprogram continues IPT involvement in the preparation of energy conservation handbooks. The new handbook for the glassworks sector, and the others already developed by the IPT for the cement, paper and pulp, ceramics, foundries and textiles sectors, aim at helping industrial technicians to implement their own energy conservation programs; and they also prove very valuable to the many energy consulting firms.

Like those already mentioned, the new handbooks will have the following contents:

- Energy diagnoses for the sector under study, with analyses of the most significant factors in determining consumption levels, with emphasis on oil derivatives and special attention to the specific characteristics of each process;

- Information on the targets and the way in which internal groups can develop and implement energy conservation programs;

- Descriptions of energy experiments surveyed in typical installations;

- Presentation of case studies on the reduction of energy consumption in the sector.

3.5 Training of Operators for Oil-Derivatives-Consuming Equipment

An in-depth energy conservation program involves the different aspects of the production process. In this regard, the IPT experiment has shown that one of the most important items in attaining the desired objectives is the motivation and preparation of the company at all levels. Thus, the re-education and training of technicians and operators is fundamental because energy conservation grows out of the direct action of these elements. In this subprogram, the IPT cooperates with, and gives technical advice to, the SENAI in the preparation of their instructors. Operators are trained directly by the SENAI, which has broad experience in this kind of activity. In this way, the industry in Sao Paulo will have progressively more and more qualified manpower to face the energy challenge.

3.6 Some Results and Difficulties

Apart from the elaboration of dozens of diagnoses and the assembly of the first duly-equipped vehicles, the printing the new energy conservation handbooks for the glassworks sector, the printing of folders containing information on energy conservation, and the thousands of operators already trained, we would like to point out the major industrial consumers of fuel oil. Table III clearly shows that the energy conservation potential of the large industries is not small, for only about 15 industries account for 2% of national fuel oil consumption.

The Energy Mobilization Program's explicit reference to the extension of the program to other regions of the country, to be led by other research institutions, backs the idea that this program - the methodology for its implementation and its results - have been correct.

The main difficulties encountered so far have been:

- Limited availability of experienced, qualified technicians, requiring the adaptation and use of less-experienced personnel and obliging a longer training period and more time spent on accomplishing the proposed tasks;

- Resistance to the program on the part of the industries themselves, which feared to reveal to the IPT information considered secret or which feared reprisals from the oil derivatives suppliers or which even had the preconceived idea that outsiders could not help. On the whole, we can say that, as the program expands, this sort of resistance is being surmounted and is becoming less rigid.

- Great difficulty in assembling equipped vehicles, due to a lack of adequate national instruments, giving rise to the need to import and thus, to delays, difficulties and higher costs, as well.

- Finally, the original time periods foreseen for carrying out the energy analyses and diagnoses were insufficient--both because of the lack of team experience and the lack of systematic information and staff in the industries, exclusively dedicated to the energy problem. In this case, it was decided to reschedule the time periods but to keep the proposed targets, which, according to opinions of industry and government, show that the program has been accomplishing its goals by using an open methodology of cooperation.

4. FINAL CONCLUSION

In our opinion, the success attained in defining, planning and implementing policies for the rational use of energy is closely related to the possibility of approaching all of these considerations and aspects in a broad, open, and cooperative way. The distortions in, or absence of, some of the following conditions have caused difficulties in carrying out these policies and have even jeopardized their feasibility:

- need for a global energy model based on consensus;
- absence of standards and conflicting energy policies between the different energy policy agents;
- establishment of realistic terms for the implementation of new policies and objectives;
- existence of realistic pricing and supply policies for energy inputs;
- resource availability, with easily-accessible and far-reaching terms for small and medium-sized industries insofar as the implementation of energy conservation programs;
- existence of a technical and scientific policy suitable for the objectives set;
- existence of training and recycling of technical staff;
- gathering, processing, systematization and dissemination of information in a broad, far-reaching and harmonious way and without duplication of efforts by the agencies involved;

Withour overriding the soundness of some of the Brazilian energy policy proposals, the issues raised in this paper show that there still is a lot to be done.

<u>IPT/CNP Program</u>

The main objective of this program is to provide technical assistance to the energy-savings program for the industries of the State of Sao Paulo.

It can be noted that, since its beginnings, this program has received collaboration from the government agents of promotion and control, from industries and their federations, and from research and training institutes.

The program, begun in 1982, has been planned to cover a three-year period, with activities developed on four major fronts:

1) Technical support to the 90 major industrial consumers of oil derivative products.

2) Technical support in establishing industrial energy-savings programs. This could be accomplished with the aid of a mobile unit containing all the necessary instruments, with such assistance destined to small and medium-sized industries.

3) Elaboration of energy-savings handbooks for use by industry.

4) Training of thermal equipment operators.

FINAL CONCLUSION

We have tried to stress some aspects which, as we understand it, must be included in any rational energy-savings planning policy for industry, and to underscore, as well, the need to overcome those difficult aspects that can be discerned for Brazilian energy policy.

TABLE I

PROJECTS		energy saved	tons./year economy	Investment Cr$/$10^3$	yearly net savings Cr$/$10^3$	pay-back (months)	Investment/oil tons saved per year US$
Installation of hot gas generator using solid fuel	wood	fuel oil	1,296	46,728	26,300	24	130.00
	coal	fuel oil	1,296	30,113	12,697	33	84,41
Boiler transformation for solid fuel burning	wood	fuel oil	755	65.186	15,976	66	313,64
	coal	fuel oil	755	49,020	7,892	100	235,86

TABLE II - CONSERVE**

	allocated funds (Cr$)	approved consultation	approved projects		
			number	loans demanded*	expenditures
1981	3,000 million	83	25	Cr$7,100 million	Cr$1,700 million
1982	18,000 million	39	30	Cr$8,700 million	Cr$13,600 million
TOTAL	21,000 million	122	55	Cr$15,800 million	Cr$15,300 million

* values to be corrected according to the ORTN indexes

** in 1983 the allocated resources total Cr$24,000 million

TABLE III - SUMMARY OF RESULTS

ENTERPRISE	FUEL OIL CONSUMPTION (ton/year)	QUANTIFIED IMMEDIATE MEASURES	NON-QUANTIFIED MEASURES	QUANTIFIED IMMEDIATE MEASURES POTENTIAL (ton/year)	PROMISING MEASURES POTENTIAL (ton or Nm^3/year)
ORANGE JUICE	21.218	9	20	2.132	10.000
CELLULOSE AND PAPER	7.186	6	32	7.711	20.000
CELLULOSE AND PAPER	37.680	14	18	15.339	24.058
CERAMICS	29.516	7	5	2.295	6.965
CERAMICS	15.127	2	7	74	8.430
CEMENT	14.900	2	4	56.760	-
GLASS	25.000	4	11	200	200 oil 4200 propane gas
GLASS	25.700	5	8	-	$9.6.10^6$ naphtha gas 392 oil
GLASS	13.420	4	8	-	$4.7.10^6$ naphtha gas
TOTAL	-	53	113	84.511	70045 oil 4200 propane gas $14.3.10^6$ naphtha gas

FIGURE I

Technological Aid Program to the Industrial Sector for Energy Conservation and Substitution of Imported Energy Sources

Funds Distribution by Type of Institution - 1982

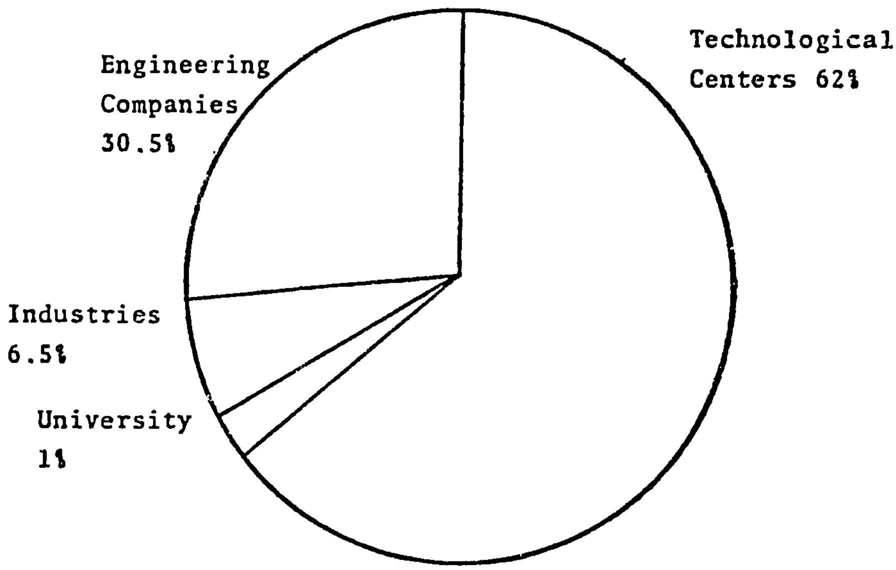


FIGURE II

Technological Aid Program to the Industrial Sector for Energy Conservation and Substitution of Imported Energy Sources.

Funds Distribution by Function - 1982

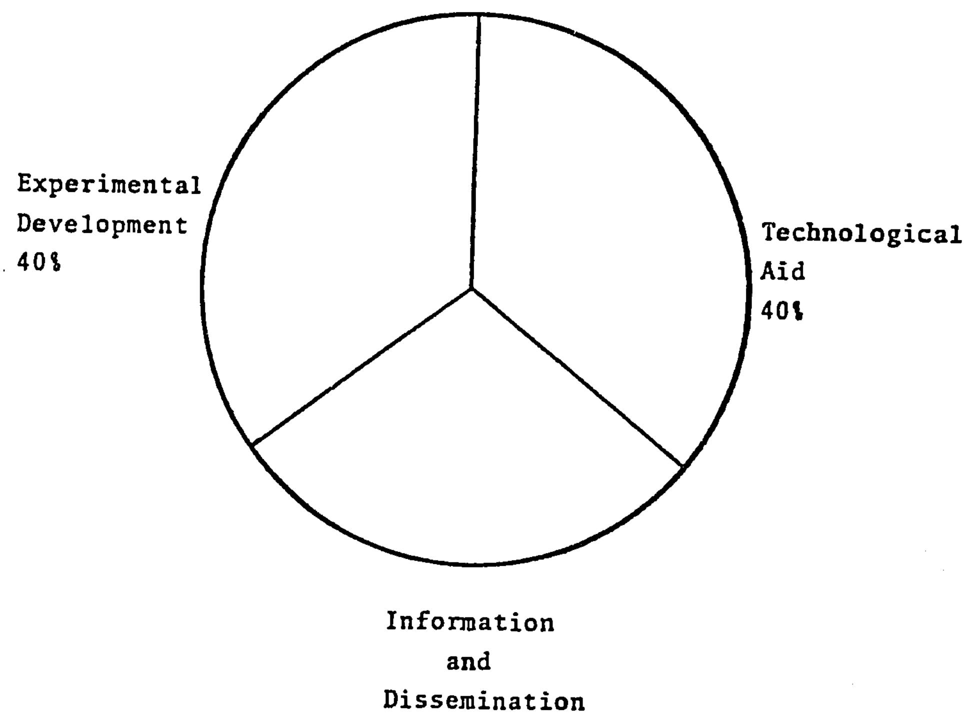
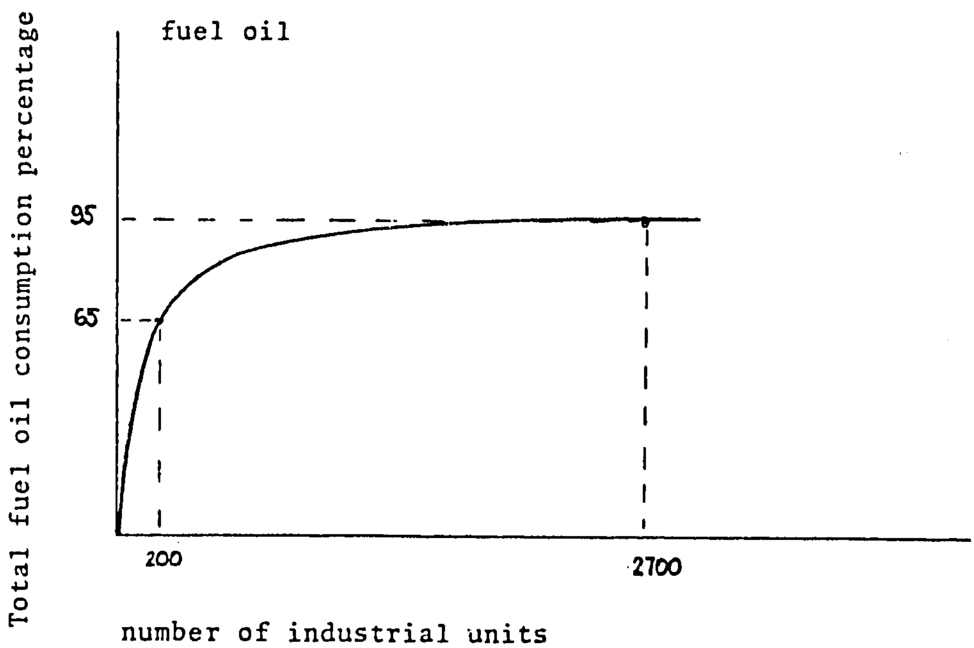


Figure III



Total fuel oil consumption percentage
fuel oil
95
65
200
2700
number of industrial units

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POLICIES FOR RATIONAL USE OF ENERGY AND INTERFUEL SUBSTITUTION "The Canadian Experience"

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Since 1974, Canada has developed and implemented policies and programs for energy conservation (the rational use of energy) and interfuel oil substitution.

These initiatives, have, in a country well endowed with energy resources, both non-renewable and renewable, been taken for a number of reasons. The main reasons are economics, concern for natural and social environments, and security of supply. Thus our major new energy supplies are more expensive in real (net of inflation) terms than our major current supplies, are in regions where social and environmental conditions are fragile, and our prospects for oil self-sufficiency remain tenuous. Rational use of energy initiatives are primarily applied to oil, natural gas and electricity, and interfuel substitution focusses on substitution of oil by renewable and other non-renewable energy sources. Both policy areas are important in each major energy use sector (buildings, industry and transport).

Today these initiatives are being reviewed and evaluated in a period of concern for leaner, more effective government expenditures, of uncertainty on future oil prices, and ten years after the demand side of the energy equation became of interest to governments.

Canada's experience indicates that:

- there is a very significant technical potential for conservation (and in many cases oil substitution) technologies to substitute for energy in the production of Canadian energy services (space heat, process heat, mobility, electric drive, lighting, etc.);

- there has been an important improvement in energy efficiency, and replacement of oil, mainly in response to real energy price increases. These increases have, in real terms (i.e. net of inflation), averaged and weighted for different energy sources, been about 7 per cent over the 1973-1983 period (See Table 1);

- the major role of non-price policy initiatives has been to reinforce the effects of price increases, i.e. to increase the price elasticity of demand for the major energy sources (oil, gas and electricity);

- there is still a considerable range of opinion as to what criteria should be applied in the analysis of energy conservation, but at the national level, comparison of the cost of saving energy (and replacing oil) units with costs of energy units from new supply sources is increasingly accepted; and

- despite improvements in energy efficiency (and oil substitution) over the past 10 years, the economic potential remaining is greater than the realized improvement; thus about 30 percent of current Canadian energy use could be saved (and current oil usage reduced by about 15 percent), without loss of comfort, convenience, mobility and industrial output, at a cost less than that of getting the same amount of energy from oil imports or new domestic supply sources (of oil, gas and electricity).

The challenge of the next 10 years will be to determine if and how this potential will be realized.

The experience and future challenges can probably be best discussed with reference to each major energy use sector each of which are important for the broad industrial sector.

Buildings

Policies for the buildings sector, concerned with residential, commercial and industrial buildings, are generally broken down into existing and new building sub-sectors.

Existing Buildings

Energy use in existing Canadian residential, commercial and industrial buildings amounts to about 40 percent of total end-use energy usage in Canada*. The potential for energy conservation and oil substitution in our existing buildings is substantial. To preserve our desired levels of space comfort throughout the year at least cost we would, over 10-15 years, cut our energy use by almost 50 percent. That is, compared with the cost of bringing on new energy supplies we could reduce energy use for space comfort (heating and cooling), etc. by about 50 percent. Cooling energy reductions would be more important in commercial building (shops, hospitals, offices, etc.) and heating energy reductions more important in residences and industrial buildings. Thus conservation technologies in the areas of insulation, reduction of air leaks, improved efficiency of heating and cooling systems, exhaust heat recovery, lighting, appliances, and hot water systems, could economically reduce energy use in existing buildings. Also gas and electricity, and in some cases, wood, could substitute for oil.

For residences, we currently subsidize conservation and oil substitution but largely rely on improved information flows for commercial and industrial buildings.

Experience indicates that if, in existing buildings, we are to apply conservation and oil substitution technologies to the point where they save energy at the same cost as producing new energy supplies, several things have to be done:

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* For space comfort (heating and cooling), ventilation, hot water, lighting, appliances and business machines; about 5 per cent of this energy is for energy services in industrial buildings.

- technology risk must be reduced: despite the oft stated view that "the technology for conservation and oil substitution is available today" many technical problems remain unresolved. Yet, even today, we do not have a systematic approach to residential energy retrofit technology, for example on solutions to the potential conflict between conservation and air quality;

- information on the why and how of energy retrofit of buildings must be better prepared and distributed. Many buildings owners, tenants, owner occupiers and those responsible for regulating occupancy of buildings (including the relationship between landlords and tenants), even today, do not understand the fundamentals of energy retrofit; and

- institutions affecting energy use in buildings must be changed to objectively consider conservation technologies and energy sources as competitors for supplying the energy services demanded by society. Here objectively means comparison of the economics and other social concerns of conservation technologies and energy sources in the production of energy services. For example the use of insulation, air tightness and efficient heating/cooling systems in comparison with oil, gas, electricity, solar energy, etc. in the least cost production of space comfort (20°C in summer and winter).

Ideally we would have institutions - energy service companies - which would competitively market guaranteed energy services such as space comfort, convenience (refrigeration, instant hot water, etc.), lighting, etc. These institutions would sell combinations of energy and conservation technologies that produced energy services at a lower cost than their competitors. But we do not have, and never have had, these institutions in Canada and so we have relied on incentives, as well as technology support and information, to simulate the ideal energy service business sector. But we are endeavouring to develop energy service institutions, through promotion of the idea, and through a company financed by the government of Canada - Canercon. Initially Canercon is working in the industrial and commercial sectors.

Our experiences with incentives for energy retrofit of residences has been mixed. The incentives are taxable grants of up to 50 percent of eligible costs, to grant maxima of $800 and $500 - for oil substitution and conservation respectively. A recent evaluation of the conservation grants indicates that over the past five years they have stimulated about 30 percent more expenditures on retrofit than would have occurred in the absence of these grants. But the energy savings achieved were lower and narrower (mainly attics) than expected, and were only marginally cost-effective.

The incrementality of the oil substitution program has not yet been determined.

Currently we are reviewing both programs and it is likely that in the future there will be increased emphasis on information, technical support and industry (retrofit companies, etc.) education and less on financial incentives.

New Buildings

As with existing buildings the economic potential for reducing the amount of energy required for space comfort, hot water, lighting, etc., is very substantial in Canada. New buildings have been constructed that use less than 30 percent of the total energy used by buildings constructed in the 1970-73 era. And the energy savings are obtained at costs competitive with obtaining energy from new energy supplies. Even in our cold winters some of these buildings require virtually no dedicated source of heat. The required heat for space comfort comes from internal and some solar heat gains.

But few of these buildings are being constructed. The reasons are a continuing tendency to minimize capital costs rather than life cycle costs, lack of knowledge of the required building techniques and disbelief that such buildings are safe, that they perform as predicted and, that their economics are sound. Incentives are not provided to construct these low energy (or super energy efficient) buildings. What we have tried to do is stimulate their construction through supporting demonstration projects, and by educating professionals, builders and the public about the benefits and costs of these buildings. For the typical new building, energy efficiency has improved by about 35 percent over the past ten years.

Industry

Including industrial buildings, industrial use of energy accounts for about 40 percent of Canadian energy usage - mainly for process heat and electric drive. The potential for energy conservation technologies to substitute for energy in the production of energy services desired by industry is substantial. Compared with a 1972 base, a reduction of energy use per unit of 1972 output averaging 50 percent across industrial sectors is regarded by industry and government as feasible. But this cannot be rapidly achieved as major process modifications are required, as well as general "housekeeping" improvements (e.g., steam trap maintenance, work procedures, etc.) and retrofit investments (insulation of pipes, holding tanks and buildings, and increased use of controls, energy efficient lighting, energy efficient motors, waste heat recovery, etc.).

Improvement since 1972 has been about 18 percent per unit of output, but much still remains to be done in the "housekeeping" and less than three-year payback retrofit investment areas. Factors retarding the improvement of industrial energy efficiency include difficult recent economic conditions, the desire for rapid investment paybacks, lack of knowledge of conservation opportunities (particularly among small and medium sized firms), and lack of credibility of conservation potential - technical and economic. This last factor holds back the development of adequate financing mechanisms as well as decisions at the corporate level to invest in energy efficiency.

The Canadian government support for industrial energy conservation has mainly been in the areas of information preparation and dissemination (publications, audio-visual, seminars, workshops), on-site energy conservation advice (energy "bus", consultant grants), and R and D and Demonstration (attempted in each industrial sub-sector).* Only in the high energy cost Atlantic region (the

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* A range of publications on Canadian industrial energy initiatives is available from the Industrial Energy Programs Division, ECOS/EMR, 460 O'Connor Street, Ottawa, Ontario, Canada.

provinces of Nova Scotia, New Brunswick, Newfoundland and PEI) have grants for conservation investments been given. These grants are only for the longer payback investments (3-8 years), which we have found are rarely undertaken by industry but which save energy at costs less than that of producing energy from new supply projects. Thus with this initiative, the Atlantic Energy Conservation Investment Program (AECIP), we have attempted to develop a program that is truly incremental, i.e. one that eliminates "free riders".

Experience with these initiatives has been mixed. The most successful initiatives appear to be those concerned with information and awareness - particularly particulary the on-site energy conservation advice offered by the energy "bus" program. This program, started in 1977, aims to stimulate awareness of and interest in energy conservation opportunities by offering free on-site advice on low cost/no cost initiatives such as maintenance procedures, and the use of controls and re-insulation. It does not aim or claim to offer comprehensive advice but only to show that by relatively simple actions conservation result are real and very profitable. Plants visited are advised that further savings can be real and significant but that they require, for their delineation and realization, more complex energy use analysis and generally higher cost/longer payback investments. These plant visits, now numbering about 9,000 across Canada, are made by engineers in buses (now numbering 20) equipped with a mini-computer, a small display area and simple energy use measuring, etc., equipment (e.g. thermography, pyrometers). The response to the program has been very positive, requests for visits cannot be met for 3-6 months, and follow up surveys indicate that about half the recommendations made by the bus crews are acted on within 12 months.

Response to support for R and D and demonstration projects has, however, been disappointing despite considerable evidence that R and D on energy conservation is lagging in Canada and that the penetration of new energy saving technologies is relatively low. Why this poor response? No clear reasons are evident but major factors appear to be a general conservatism towards plant energy efficiency, and a lack of awareness of the significant economic technology advances that are available, coming available or promising. As yet is too early to assess the investment support program (AECIP), but response in the first 18 months of its operation has been encouraging.

In the area of oil substitution, Canada operates two programs for industry - the Forest Investment in Renewable Energy (FIRE) Program, which gives grants of up to 20 percent of investments in conversion from (mainly) oil to biomass and general solid waste energy sources, and the Industrial Conversion Assistance Program (ICAP), which gives grants of 50 percent of costs of converting from heavy fuel oil to natural gas. FIRE is essentially a biomass and solid waste marketing program, and ICAP is essentially a natural gas marketing program. FIRE has been in place for about 4 years and has, to some extent, stimulated conversion from oil (and also from natural gas and electricity) to "biomass" sources. But its incrementality is limited and in today's economic conditions the program is almost dormant.

ICAP was only launched in 1983 and seeks to build markets for natural gas network expansion which, in the long run, it is hoped, will permit considerable oil substitution.

Transport

Transport of people and goods accounts for about 25 percent of Canadian energy use. In our use of energy for transportation of people we have been typical North Americans. We have relied almost totally on private transportation in fuel inefficient automobiles, on oil products as an energy source, and we have a declining passenger rail industry. Overall, the energy efficiency of our transportation systems has been low by comparison with other countries.

Our energy policy for transportation has two major elements:

- improvement in the energy efficiency of all modes, particulary road transportation which accounts for about 70 percent of all transport energy

- substitution of other fuels, particulary propane (LPG) and compressed natural gas for gasoline and diesel fuels in road transportation

In the area of increased energy efficiency, significant progress has been made, particularly in the road and air modes. For road transport, automobiles dominate energy use and on-road fuel economy of new automobiles has increased by about 25 percent since 1976. But this improvement could be much greater if automobiles sold in Canada were designed to equate the marginal costs of supplying energy and of improving fuel efficiency in the Canadian cold weather conditions which prevail for 6-8 months of the year. Currently another concern is that the perception of "soft" oil prices and the employment impacts of auto imports is slowing the improvement in automobile fuel efficiency. In substitute fuels, the commercial and industrial sectors are the main users.

Gasoline and diesel fuel substitution is being actively pursued in Canada, particularly for road transportation. Today propane, a fuel in excess supply in Canada, is the main substitute fuel, with an ultimate substitution potential of about 10 percent of current gasoline and diesel usage. But in the future compressed natural gas and methanol - both fuels for which Canada has a substantial resource base - are expected to become more important. In substitute fuels, the commercial and industrial sectors are the main users.

Review of Conservation and Oil Substitution Technology Opportunities

The previous sections of this paper have addressed broad opportunities for conservation and oil substitution technologies in each of the major energy using sectors. But in addition it is useful to review the methodology for comparing specific opportunities with energy supply opportunities and to outline some conservation and oil substitution opportunities.

Demand/Supply Comparison Methodology

For demand technologies, the costs of obtaining additional energy savings must be compared with the costs of new energy supplies. For example, the cost of a marginal increase in the thickness of insulation on a steam pipe, say $x per centimetre, must be evaluated by considering the energy savings, over a realistic life, say 10 years (usual for industry), discounted at a similar rate (say 10 percent real) used for the evaluation of energy supply projects. By dividing the discounted energy savings (in gigajoules) with the marginal insulation costs (plus the present value of any incremental operating costs), the cost per gigajoule (GJ) of the energy saved may be computed. This per GJ cost can then be compared with the cost (similarly computed) of energy from new supply sources that could be used to produce the steam in the pipe.

In national decision making the economics and the amounts of energy "saveable" (from all such opportunities) at costs less than the costs of new energy supply must be considered.

<u>Conservation and Oil Substitution Technology Opportunities</u>

Listed in Tables 2, 3 and 4, are the major technologies that need to be considered in analyses of the type outlined above. Energy savings can also be obtained from sources such as preference changes (e.g., smaller autos, indoor temperature reductions in winter, etc.) and work maintenance schedules (industrial energy equipment maintenance, auto tuning, home furnace tuning, work scheduling, scrap reduction, etc.). But these savings can be lost as preferences change, and as other maintenance/work schedule items receive priority. One might call these sources "reversible" conservation. On the other hand savings from conservation investments, e.g., in insulation, heat recovery, and improved auto engine efficiency, are less likely to be reversible. Hence the Canadian policy is to concentrate on this "irreversible" conservation.

Similar situations occur with respect to oil substitution, e.g. the possible temporary use of wood stoves to replace oil usage in the heating of Canadian homes (reversible) compared with replacement of an oil furnace with an electric resistance furnace.

The possible overall effects of applying energy conservation and oil substitution in Canada are illustrated in Figure 1. Scenario I indicates the possible effects of an aggressive approach to realising cost-effective (economic compared with new energy supplies) conservation and oil substitution opportunities. Scenario II indicates the forecast effects of current programs and price projections.

Summary

Canada's experience with energy conservation and oil substitution policies over the 1973-1983 period indicates that:

- there are significant opportunities for the reduction of energy (particularly oil) usage in the production of the goods and services demanded by Canadians at a given level of GNP;

- since 1973, a period of increasing real energy prices and increasing attention to energy conservation and oil substitution possibilities, there has been a significant decrease in energy (particularly oil) usage in the major energy using activities in Canada;

- despite this improvement, the remaining potential to substitute conservation technologies and other energy sources for energy and oil respectively, is very substantial at costs less than those of bringing on new natural gas, electricity, coal and oil projects;

- significant energy conservation potentials remain in the major energy services - space comfort (heating and cooling), hot water, convenience (appliances, etc.), process heat, electric drive and lighting;

- significant oil substitution potentials remain in the space comfort (heating) and transportation energy services;

- the main problems retarding and preventing these economic potentials being realized are:

  - non-marginal cost pricing of energy;
  - lack of adequate general and specific information on the why and how of energy conservation and oil substitution;
  - lack of adequate analysis of why (technically, economically and institutionally) energy is used;
  - lack of adequate analysis of the combination of energy and energy conservation technologies, and the required technical, economic and institutional conditions, that would produce energy services at the least possible cost;
  - lack of adequate financing arrangements which are caused by:
    - lack of institutions aware of the potential to finance and sell least cost energy services such as space comfort, mobility, convenience, process heat, electric drive, and lighting
    - fiscal (tax, expenditure) arrangements
    - technological and economic uncertainty

Each of these factors are being addressed in Canada but no really effective solutions to these problems have yet been found. But the search continues, because of the perception, and growing evidence, that potential net benefits from effective solutions are substantial. That is, much energy, particularly oil, can be economically "produced" by efficiency and substitution initiatives if the segment of the energy industry that is based on energy demand management is encouraged to develop its full potential.

Our experience is, like other countries, unique to our situation. Nevertheless, I believe that the principles one can draw from this experience are broadly applicable to other countries around the world.

TABLE 1

ENERGY PRICES IN CANADA - SELECTED YEARS

RESIDENTIAL SECTOR - CANADIAN WEIGHTED AVERAGE
(1950 DOLLARS)

	HEATING OIL (PER GALLON)	NATURAL GAS (PER 1000 CU. FEET)	ELECTRICITY (5000 KWH PER YEAR)	MOTOR GASOLINE (PER GALLON)
1950	$0.18	$0.93	$57	$0.41
1960	0.15	0.78	47	0.32
1970	0.12	0.62	31	0.29
1973	0.13	0.55	32	0.29
1976	0.17	0.71	34	0.32
1977	0.18	0.78	37	0.33
1978	0.19	0.82	39	0.32
1979	0.20	0.82	39	0.31
1980	0.21	0.88	40	0.32
1981	0.25	0.94	42	0.38
1983	0.30	1.13	45	0.45

TABLE 2

CONSERVATION AND OIL SUBSTITUTION TECHNOLOGIES IN BUILDINGS

TECHNOLOGIES	STATUS IN CANADA*
Insulation	- some improvement (P,S)**
Air Tightness	- some improvement (P,S)
Heat Recovery from Exhaust Air and Waste Water Streams	- usage just commencing (P,S,LTP)
Lighting (phasing out of incandescents, use of higher efficiency fluorescents, etc.)	- some improvement (P,S)
Controls (for temperature, humidity, lighting, air flows)	- some improvement (P,S)
Improvement of Appliance Technologies	- some improvement (P,S)
High Efficiency Heating (elements, heat pumps, furnaces, etc., and systems)	- some improvement (P,S)
High Efficiency Cooling (elements, systems)	- little improvement (P,S)
Windows (orientation, glazing/air gaps, shutters, etc.)	- some improvement (P,S)
Oil Usage	- dropping (P,S)
Biomass Usage	- growing (P,S)
Natural Gas Usage	- growing (P)
Electricity Usage	- growing (P,S)
Solar Energy Usage	- at RD&D stage (S,LTP)

* Besides the application of technologies, energy savings in buildings are coming from sources such as lower winter and higher summer indoor temperatures and improved maintenance procedures.

** Letters in brackets refer to current economics of the technology categories: P to those economically viable to energy users (better than 5-year paybacks); S to socially viable (competitive with energy from new projects); LTP to longterm potential for social and/or private economic viability. Note that many sub-categories differ in their current economics.

TABLE 3

CONSERVATION AND OIL SUBSTITUTION TECHNOLOGIES IN INDUSTRY

TECHNOLOGIES	STATUS IN CANADA*
Insulation (buildings, pipelines, process equipment sotrage tanks)	- some improvement (P,S)
Waste Heat Recovery - Heat Exchange, Upgrading	- some improvement (P,S)
Process Control	- some improvement (P,S)
Combustible Waste Recovery and Use	- some improvement (P,S)
High Efficiency Lighting (high efficiency fluorescents, high and low pressure sodium, etc.)	- some improvement (P,S)
High Efficiency Electric Motors	- little improvement (P,S)
Thermal Storage - Often Linked with Waste Heat Recovery	- little usage (P,S,LTP)
Heat Pumps - Often Linked with Waste Heat Recovery	- usage just commencing (P,S,LTP)
High Efficiency Combustion	- usage growing (P,S)
Low Energy Processes	- usage growing (P,S,LTP)
Cogeneration	- little new capacity over the past 10 years (P,S,LTP)
Oil Usage	- usage dropping (P,S)
Biomass Usage	- significant improvement in pulp, paper, wood products sectors (P,S,LTP)
Natural Gas Usage	- growing (P,S)
Electricity Usage	- growing (P,S)

* Besides the application of technologies, industrial energy savings are coming from sources such as improved maintenance procedures (e.g., for steam traps, hot water lines), increased production rates, and reduced scrappage rates.

TABLE 4

CONSERVATION AND OIL SUBSTITUTION TECHNOLOGIES IN TRANSPORTATION

TECHNOLOGIES	STATUS IN CANADA*
Automobiles and Trucks*	
Improved Engine Efficiencies (diesels, stratified charge, etc.)	- some improvement (P,S,LTP)
Improved Cooling System	- little improvement (P,S)
Improved Transmission	- little improvement (P,S,LTP)
Better Lubrication	- some improvement (P,S)
Weight Reduction	- increasing use of higher strength to weight ratio materials (P,S,LTP)
Radial Tires	- significant usage (P)
Improved Aerodynamics	- significant improvement now occurring (P,S)
Oil Usage	- dropping (P,S)
Propane Usage	- growing (P)
Compressed Natural Gas Usage	- just commencing (P,S)
Alcohols Usage	- virtually unused (P,S,LTP)
Electric Vehicles	- still at RD&D stage (LTP)
Other Modes	
Urban Transit Improvement	- some improvement in availability and scheduling (LTP)
Airplanes of Higher Energy Efficiency (e.g., motors, controls, aerodynamics)	- significant improvement now occurring (P,S,LTP)
Rail Improvements (e.g., LRC, track, controls)	- some improvement (P,S,LTP)

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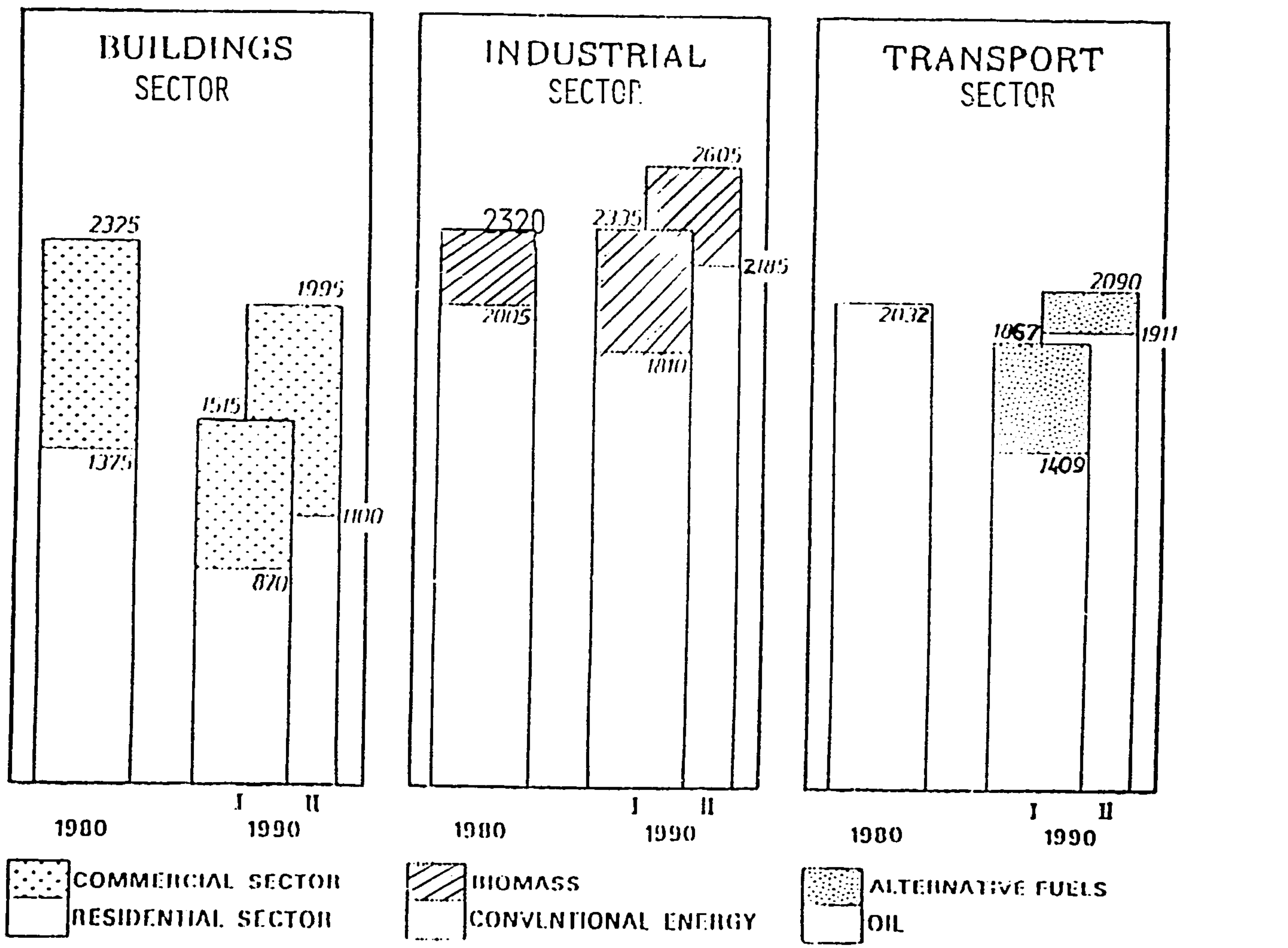
* Besides technology improvements, a greater proportion of small autos is reducing transport energy usage in Canada.

FIGURE I

ENERGY USE BY SECTOR IN CANADA 1980-1990 (PETAJOULES)

I: AGGRESSIVE COST EFFECTIVE CONSERVATION AND OIL SUBSTITUTION

II: FORECAST WITH CURRENT PROGRAMS AND PRICE PROJECTIONS



Energy Conservation in Industry and Transfer of Technology

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I INTRODUCTION

It has been estimated that industry accounts for 76% of the world's total consumption of petroleum natural gas and coal. The industrial share in the consumption of electricity and other energy sources is also significant. This, and the fact that energy is a scarce and costly item, justifies any effort made to improve the efficiency of energy use in the industrial sector, since the capital investment required to save or conserve one unit of energy is less than that required to produce another, new unit.

Interest in saving and conserving an energy unit in the industrial sector is directly related to the resulting economy, meaning that energy conservation policies are closely tied to pricing and incentive policies.

Therefore, policies that will promote energy saving and conservation in industry must be assigned top priority.

Efforts to adapt, develop and transfer technology to rationalize energy consumption depend not only on international energy prices but also on countries' internal price structures.

To encourage this adaptation, development and transfer of technology to improve the efficiency of industrial energy consumption, the role of conservation in this sector should be taken into account as well as pricing and incentive policies and the criteria related to technology transfer mechanisms must be reviewed.

II. THE ROLE OF ENERGY CONSERVATION IN INDUSTRY

During the past decade, the industrial sector, which developed in an era of cheap and plentiful energy, has been penalized by high energy prices and unstable fuel supplies.

During this period, the energy consumption growth rate in developed countries slackened from the previous decade's 7.5% to under 1%. This slowdown was the result of both the economic slump and efforts towards savings and conservation.

In comparison, developing countries, which require high energy growth rates to upgrade their present standards of living, have also seen a decrease in their energy consumption growth rate - from 8.5% to 6.5% during this period - mainly due to rising fuel prices and the worldwide recession.

In general, given the high level of industrial consumption, energy savings and conservation policies could make a positive contribution to the world economy's recovery process.

Such a policy will call for immediate recourse to technology transfer and adaptation, to be followed by the development of more energy-efficient technology in the medium and long terms.

Energy conservation programmes in industry have as one of their foremost objectives a lower energy/product ratio. Other benefits include a reduced working capital and an increased profit margin.

Conditions that will contribute to the attainment of these objectives include:

- Institutional structures that will support and promote such activities and reliable statistics on energy consumption and industrial production levels.

- Fiscal incentives and economic resources to finance investments.

- Regional collaboration programmes supported by international agencies.

- Unification of criteria and methodologies for energy audits in industry.

Isolated energy conservation projects, even when they benefit given sectors of society, do not have the same impact as those projects that are developed within national and/or regional programmes which would, by their nature, affect overall energy consumption levels and should therefore be taken into account when forecasting national and regional consumption in the preparation of energy development plans.

III. ENERGY PRICING POLICY

The impact of energy pricing policies on Latin American countries has not yet been subject to a sufficiently in-depth analysis because the basic tools of analysis are lacking. Methodologies are still under preparation. The studies that have been carried out have merely focussed on the quantitative elements and have neglected the qualitative ones.

The absence of a methodology that can integrate both elements is primarily due to the fact that these countries based their economic and social development on the use of cheap and plentiful resources which replaced other factors of production. The relative abundance of energy and its inefficient use did not favour the elaboration of methods that would allow for objective analysis of the repercussions of fuel price changes on the countries' economies.

So far, the analytical methods have basically responded to political and conjunctural situations giving rise to domestic energy price structures that have often contributed to distortions in the fuel markets. These methods have not permitted systematic evaluation of the forces acting on each economic variable.

This does not mean, however, that sophisticated methodologies which are expensive and hard-to-handle should be developed. It does mean that it would be advisable to develop approaches that will allow the most accurate measurement of the impact of energy pricing changes at both domestic and foreign levels so that energy policy may be developed in tune with the economic and social development needs of the people. The methods chosen should interrelate the socio-economic system and the energy system.

The lack of an adequate energy pricing policy leads to inefficient energy use by developing countries, both net exporters and importers of energy. Some energy-exporting countries keep their domestic prices far below international prices which provides little motivation to change energy consumption patterns. The future consequence may be lower energy-use efficiency in such countries than in others with similar levels of development.

The decision to save and conserve energy, above all in industry, in order to maintain appreciable profit margins, is the outgrowth of domestic energy pricing policy. Therefore, efforts to adapt, develop and transfer technology to rationalize industrial energy consumption depend on pricing policy as well.

IV. ENERGY CONSERVATION INCENTIVE POLICY

Industry in Latin American countries is based on an energy- and capital-intensive technological model, often out of touch with the socio-economic and cultural reality of these countries. This model will also soon become obsolete, made impractical by the heavy financial constraints that these countries will have to bear.

For these reasons consideration should be given, within economic and energy policy measures, to accompanying investments in industrial energy conservation and savings by incentives that will make this approach more attractive than other alternative investments that could compete for the available financial resources. Some alternative investments have been provided with incentives ranging from partial or total exemption from import duty to liberation from payment of income tax on profit margins.

Incentives policy must lead developing countries to adopt energy models that will permit the use of more accessible technology requiring less capital and foreign financing and making better use of the labour force which is the most abundant production factor in the lesser-developed countries. In this same vein, incentives policy must also favour tapping local energy resources such as wind energy, solar energy, biomass and hydroenergy.

Ultimately, incentives must be created to promote all action that will tend to conserve and save energy in the industrial sector and to use appropriate technology.

The incentives mechanisms that could be used include the following:

- Financing programmes for industrial energy audits.

- Financing programmes for replacement and purchase of more efficient machinery and equipment.

- Training of human resources in energy savings and conservation.

- Facilities for financing the development of appropriate and energy-efficient technology.

- Partial or total waiving of import duties on capital goods aimed at local production of machinery and equipment for the development of the energy industry.

V. TECHNOLOGY TRANSFER, DEVELOPMENT AND ADAPTATION FOR ENERGY CONSERVATION IN INDUSTRY

Technological development is not uniformly distributed throughout the world, but rather largely concentrated in the industrialized countries. The build-up of technological development is not only the result of a group of factors and historical, cultural and geographical circumstances but the fruit of efforts and sacrifices by the people and their leaders as well.

Sad to say, the results of many investigations done in advanced nations are not directly applicable to developing countries because such results are fundamentally attuned to the needs of the former.

It has been estimated that a mere 2% of the world's research and development efforts are devoted to technological research for under-developed countries, while the remaining 98% is geared to solving the problems of developed countries.

Developing countries must import technology if they are to achieve economic growth. Relatively more-developed nations, however, must rely on basic scientific and technological research as the only approach that will, in the long run, ensure the creation of technology that matches their needs.

Despite the developing countries' crying need to transfer technology, it is particularly important that they modify, in some respects, the current transfer mechanisms in order to optimize this process.

It is not a question of simply resorting to international technical assistance just because it may be offered along with financial assistance, it is necessary to determine what is expected from such aid and how it can contribute to social, economic and technological development.

Both developed and developing countries should regulate the flow of technology because unrestricted transference mechanisms have produced higher capital costs and have, in many cases, limited countries' ability to generate technological decisions congruent with their needs.

Other barriers that also play a part in hindering the process of technology development and adaptation include the following:

1. Shortage of human, technical and specialized administrative resources to develop and adapt technology.

2. Insufficiently inter-institutional coordination and integration.

3. Few points of contact between the institutional structure and the industrial sector.

4. Policial factors and the absence of economic incentives.

5. Socio-cultural differences.

6. Lack of incentives and stimuli for new savings and conservation technology.

7. Lack of policies suitable to the reality of these countries.

All these difficulties suggest the need to expand the sharing of technology and information among countries, in order to surmount these and other hindrances that have impeded efficient energy use.

There are some measures that could be taken to counteract the negative effects of the hurdles listed above:

1. For countries receiving technology to have the institutional infrastructure and qualified human resources that they need in order to choose the technology that best fits their conditions.

2. To avoid the transfer of technological packages as this transfer procedure creates on-going dependence.

3. To improve national and international information systems.

4. To transfer technology only when it will tend to satisfy the basic needs for technological, political and social development, measuring success not only in terms of limited economic profits but also in terms of social development.

5. To take into account the social and cultural customs prevailing in the receiving countries.

The interrelation that exists among the criteria mentioned above implies that any limitation in the application of any of them may slow or even stop the process of development and adaptation of technology.

Given the important contribution that energy-savings and conservation programmes in industry have to offer towards the recovery of many economies, international agencies should lend their support to improvements in the traditional mechanisms of development and transfer of technology.

Thank you.

EUROPEAN COMMUNITY ENERGY DEMONSTRATION SCHEME

Ubaldo Zito
Head of Energy Savings Division
Commission of the European Communities
Brussels

1. The European Community Energy Demonstration Scheme is conceived in the context of the Community Energy Strategy for which the 2 main pillars are to:
   - use energy efficiently;
   - reduce our dependence upon oil, by substitution of other fuels.

2. It is well to bear in mind how the Community uses energy. The 3 largest energy using sectors are:

Buildings	35%
Industry	35%
Transport	25%

Already the Community has reduced its oil dependence from some 60% in 1973 to 50% in 1982.

3. Experience has shown that it is not enough to pursue an active energy R&D programme to achieve the necessary technological innovation to help achieve our Energy Strategy. Many successful research findings, patents and know-how remain unexploited because they are not adapted for exploitation.

   There are two main reasons for this:
   - the current depressed economic circumstances;
   - the high risks which inevitably attend the first attempted commercial realization of technical innovation.

4. Over the past three years, the Community has been operating a financial support scheme for energy demonstration projects. Such demonstration projects link the R&D stage, sometimes tested on pilot plant, and the later investment stage. It differs from the R&D and pilot stages in the industrial scale of the projects, the requirement of having prospects of economic viability, and from the normal investment stage in that the inherent risks are still considered by the entrepreneurs to be too high.

5. The idea is that a substantial part (sometimes up to 49%) of the financial risk of a Community Energy Demonstration Project, which is innovatory in character, is borne by the Community. Such a project must have real prospects of commercial use and must be capable of encouraging other installations of the same type in the Community.

6. The system works like this: project proposals are received from enterprises in response to a published call for tenders. They are then scrutinized and with the help of a Consultative Committee composed of Member States experts, the Commission selects a number of the best proposals. The successful project proposers engage in a contract with the Commission to carry out a defined programme of work and to provide a full final report suitable for publication. The financial responsabilities and respective rights of the parties to the contract are defined and, in the event of success, there is provision for repayment of Community financial support over a period of years. Repayment is thus a convenient index of success. If the project is not a success, no repayment is required.

7. Nevertheless, it is important to make known not only successes, but also the results of projects which fail to achieve their objectives and the reasons why, so that others may avoid fruitless work. Dissemination of results both good and bad is essential and the Commission is using a variety of means to this end:

- newsletters and bulletins;
- symposia;
- articles in trade journals; and
- a computer-aided information service.

8. The technical fields covered by this Community Demonstration Programme have up to now included:

- energy savings;
- alternative sources:
  - solar energy including biomass
  - geothermal energy
  - coal gasification and liquefaction

with a financial scope of just over 200 mecu.

9. Although most projects last three years or even longer and the scheme has only been in operation for three years, we have recently carried out (with the help of independent experts) and published an extensive evaluation of progress so far. Over 1400 project proposals have been made to the Commission representing a total investment of about 4000 mecu. So far some 330 projects have been selected and it is estimated that the 200 mecu support granted stimulates investments of about 900 mecu, not counting the subsequent multiplicative effects of successful demonstration. Among the prospects so far selected there are 27 in the industry sectors. (Please see full report in Annex A).

As far as R&D is concerned, the Community has been running since 1975 a programme of financial support, namely in the energy saving field. Altogether the Community budget has been involved in support for some 270 R&D projects, some of which are already close to application.

II. Energy Analysis and Advice

1. Another area of activity at Community level is closely related to the previous point: it is the provision of analysis and advice.

We are engaged in a series of Energy Audits, to examine the energy consumption of selected industries, at European level.

The idea is first to draw up a check-list of measures which are already being taken somewhere within a given industry and which could be more widely used; and, second, to identify new measures which would permit further energy savings.

The first three Audits will be published this year, covering the iron and steel industry, aluminium and pulp and paper. Work is already in hand on the chemicals and glass industry. (Please see the summary of the Aluminium Energy Audit in Annex B).

2. The Commission is also supporting the operation of Energy Buses.

I wonder how many of you have heard of them?

The energy bus is an idea pioneered by the Canadians, and now in operation in every Canadian Province.

It is a vehicle equipped with all sorts of computer gadgetry.

At the request of a given firm, it can turn up on site; and, by analysing various data, it can produce very rapidly a complete energy balance, and indicate measures that could be taken to reduce consumption.

There are now 10 of these buses operating in four Community Member States; Belgium, Netherlands, Italy and Germany. Ireland is also associated with the programme.

I hope this briefing has given you a rough impression of our programmes and instruments for a more rational use of energy.

If you are interested in any particular project or newsletter, please contact us. I will be pleased to offer my collaboration to help you as far as possible.

Unfortunately, tomorrow I will not be here with you for the closing session so I would like to say tonight how pleased I was to share with you some of our European experience.

A Seminar like this - a happy complement to the Cartagena meeting - represents a valid and faithful instrument to implement a deeper energy cooperation between Europe and Latin America.

For the future and in the light of our results here this week, the Commission of the European Communities will be farlooking in considering the establishment of a permanent cooperative link with OLADE in order to have a continuous exchange of information on energy matters of reciprocal interest.

For my part - you can be assured - I will recommend that such an important cooperation be rapidly materialized.

A.1. INDUSTRY

A.1.1. Introductions

Industry is "par excellence" the big energy-consuming sector. Leaving aside the energy content of raw materials, industry's energy consumption in 1980 was 227 million toe, equivalent to 35 % of the Community's final energy consumption.
The possibilities for the more rational use of this energy are any and vary widely, depending on the industrial sectors involved. Nevertheless, two main categories may be identified :

- *"horizontal" measures :* these include improving the heating of buildings, optimizing the efficiency of industrial boilers, using more efficient equipment (e.g. pumps, electric motors, heat exchangers, etc.). The demonstration programme in respect of these measures covers a range of sectors;

- *"vertical" measures :* these mainly concern improvements to manufacturing processes (using techniques to regulate and control energy flows, use of cascade heat) and the recovery of heat, at present lost, for CHP and/or district heating.

The potential energy savings to be made in the industrial sector may be put at 50-60 million toe, i.e. 20-25 % of consumption in 1980.

A.1.2. Specific industrial sectors and Community action

a) *Iron and steel*

I. Introduction

The iron and steel industry is the biggest energy consumer. In 1980, it accounted for 8 % of the Community's primary energy consumption.
There is considerable scope for energy recovery in this industry because not only is the efficiency of modern integrated plants low (50-60 %) but also the production of steel generates significant energy flows, basically in the form of heat. In view of the high process temperatures involved, these heat flows possess valuable thermodynamic properties which not only allow the heat to be recycled but also allow it to be used to generate electro-mechanical power.
The generally high cost of heat-recovery plant, however, meant that not even the most promising recovery systems seemed worth considering when energy was cheap. In addition, the steel makers felt a very understandable aversion to the idea of further complicating the main production operation which was already very complex and costly.
Today the situation is quite different and the potential savings from certain methods of energy recovery are beginning to persuade the steel industry to introduce the most promising techniques even if this means a slight reduction in the reliability of the production apparatus which is inevitable whenever auxiliary plant components are added to the main system.
There are currently 15 major energy-saving options open to steel firms (these options are followed by a + sign where they specifically relate to integrated-cycle steel works and by a ++ sign where they concern furnaces which use scrap) :

- rationalization of energy use during the blowing operation (+);
- recovery of heat from the hot-blast stoves (+);
- recovery of energy from the blast furnace gas by means of a turbine (+);
- direct or indirect recovery of heat from the combustion products in the converters during blowing (+);
- recovery of heat from the shells (of the furnaces and converters) and from the steel treatment plants;
- improved operation of electric furnaces (++);
- recovery of heat from the combustion products in electric furnaces (++);
- pre-heating of scrap (++);
- recovery of heat during the warming-up of refractory materials used in casting ladles and other containers;
- conserving the heat from semi-finished products (ingots, slabs, billets, etc.);
- application of heat tratment to semi-finished products (e.g. wire rod) after rolling;
- application of unconventional methods of heat treatment;
- regulation of the rolling force;

- streamlining of the auxiliary services in order to save energy (heat, power and blowing plants; oxygen production, storage and supply installations; coking plants etc.);
- automatic or semi-automatic programming of the production and maintenance operations.

The above options may lead to practical results if use is made of the – often very different – range of technical alternatives available. The scope for action is thus very wide. In the short and medium term, the energy saving may be estimated at 10 or 15 % of current energy consumption, i.e. 7-10 million toe/year.

II. Community action

Contracts for nine projects have been concluded or are shortly to be so, seven of which have been submitted by steel companies, one by a research institute and one by a mechanical engineering firm.

The total investment in these projects is about 26 million ECU and overall financial support 7,200,000 ECU.

In six of the nine cases the projects are in fields of general interest to all steelmakers, i.e. ;

- recovery of heat from hot-blast stoves;
- installation of turbines to extract mechanical energy from the pressurized hot air at the furnace throat;
- recovery of heat from waste converter gases;
- pre-heating of the scrap charge to the electric furnaces by using the combustion products from the same furnaces.

Similar projects – all of great interest – are also being carried out or are planned in a number of other European steel firms.

The areas covered by the three other projects are more specific.

One aims to increase the power of electric furnaces and to achieve energy savings by making suitable alterations. The other two projects being run by firms with no connection with the steel industry and which are of interest to the metal-working industry as a whole, concern the heat treatment of steels by unconventional methods (fluidized bed or recovered heat). In six cases, the projects aim to optimize the efficiency of industrial processes: in the three others (EE/246/81; EE/074/80; EE/270/80) the aim is to recover fuel gas and/or generate electricity.

The research and development phase of project EE/074/80 has been partly financed from central government funds by the Energy Savings Agency.

III. Conclusions

The situation with regard to the nine projects is as follows :

- three are still at an initial stage and it is too early to make an assessment;
- five are in progress. No major problems have been encountered in their execution and, in at least three cases, there is every likelihood that the anticipated energy savings will be achieved;
- only one project has been completed (EE/251/79) and the results are far better than expected : the energy savings achieved are twice the forecast level.

The energy savings achieved by implementing these nine projects amount to about 147,000 toe/year.

b) Non-ferrous metals

I. Introduction

In terms of energy consumption, this sector comprises mainly aluminium, copper, zinc and lead. The consumption of the non-ferrous metals sector represents almost 9 % of the final energy consumed by industry.
The use of energy in this section can be subdivided into two distinct sections :
(1) production of primary metal from raw materials. This process applies essentially to the aluminium and zinc industry and to a lesser degree to lead industry; virtually all European copper production is derived from scrap and imported refined copper.
(2) the melting, casting, rolling extrusion of metal into finished products.
In the aluminium industry, the total energy consumption is about 12 M toe/year and for example, 70 % of the energy demand (mainly electrical) is consumed for primary smelting, the specific energy demand of 30 to 50 GJ/tonne for the subsequent operation.
The energy conservation trend for the primary smelting operation is along the lines for improved furnace minor design changes by the control of electrolyte temperatures, using additives, re-arrangement of magnetic fields, etc., modern design of smelters yield consumptions of 16,000 kWh/tonne compared with older designs of 20,000 kWh/tonne.
In the secondary processes the main activity in energy conservation is involved in converting to continuous melting and processing from batch type operations. It can be shown that significant reductions in energy demand can be achieved resulting from reduced standing losses and better product qualities. Interest is also being shown in pre-heating furnace designs to reduce metal losses due to excessive oxidation.

II. Community action

In the non-ferrous metals sector three demonstration projects have been signed dealing with melting or smelting of aluminium, copper or non-ferrous alloys.
Two projects come from the same proposer, the Electricity Council Research Centre, one from the first call for tender in 1979 and the other from the third call in 1981. Both are follow-up of R & D work done by the proposer and the applications at demonstration level take place in industrial enterprises. Due to the limited investments involved, the EEC financial support is 40 % for each of them. The third one is a joint effort by companies from Belgium and Germany who joined their R & D effort and decided to invest in a large industrial demonstration with a 30 % financial support from the Community. For this project only, the energy savings foreseen are 5,000 toe/year.
For these projects, the EEC support represents about 2.1 MECU for a total investment of 6.76 MECU.

c) Cement & Building materials (bricks, lime)

I. Introduction

Since the processes require high temperatures, the cement, lime and building brick industries are necessarily energy intensive. The raw materials used in these industries are cheap and the major cost of production is the energy used in the high temperature process. Consequently, any energy saving is also a significant cost saving.

(a) Cement & lime

Both production processes involve calcining at temperatures up to 1400°C. In cement clinker manufacture, this is carried out in rotary kilns. Lime is manufactured in rotary kilns or vertical retorts depending on the lime quality required and the production rate. On large installations the principle fuels are pulverised coal and heavy fuel oil, smaller units producing high quality lime use premium fuels such as natural gas and distillate oils.

In the manufacture of cement almost 90% (6,5 GJ/tonnes cement) of the energy used to produce the final product is consumed in kilns to produce cement clinker. It is not surprising therefore, to find that close attention is given to improving the design and operation of these kilns by more efficient firing, recovery of exhausted heat and improved insulation refractory material. With such an energy intensive area of the industry a small improvement in kiln performance represents a significant primary energy saving.

In cement manufacture the following energy conservation measures are currently being pursued :

1) wet to drier process conversions;
2) waste heat utilisation (improved clinker cooling);
3) insulating refractories development;
4) blended cements (p.f.a. and blast furnace slag);
5) slurry moisture additives development;
6) specification changes (gypsum blending);
7) improved grinding techniques and use of grinding aids;
8) fixation of alkalis in kiln dust;
9) use of refuse derived fuels.

The potential energy saving from the above is of the order of 40%. In lime manufacture the potential for energy conservation is more varied due to the wider variety of equipment in use.

The main areas being investigated are :

1) combustion systems development;
2) waste heat utilisation;
3) insulating refractories development;
4) fuel substitution (use of coal gasifiers etc.);

The potential for energy saving is of the order of 30%.

(b) Building Brick Manufacturers

The manufacture of bricks and other earthenware products involves materials preparation, low temperature drying at approximately 120°C and final firing at 800°C-1,000°C.

If hot air from the firing kiln is used in the drier, 80/90% (1.8/2.0 GJ/tonne bricks) of the total primary energy consumed to produce bricks can be used in the kiln. Main areas of interest in energy conservation include the use of carbonaceous wastes as an additive to some clays before firing, the recovery of heat from kiln exhaust and improvement in firing equipment.

The main area for energy conservation is in the final firing which is generally carried out in tunnel kilns.

The main areas being investigated are :

1) recovery of heat from exhaust gas from continuous kilns;
2) addition of carbonaceous wastes to raw materials before firing.

The potential for energy saving is of the order of 30%.

II. Community action

In this sector, 3 projects have been signed, one for the brick industry, where by using pulverised coal energy saving up to 60% can be expected. Normally, fuel substitution from oil to coal leads to penalties in terms of primary energy consumption. In this case, by using the latest technology for burning coal, it is possible to switch away from heavy fuel oil and still obtain significant energy savings. The replication potential is large and many parties have already visited the site of the demonstration project .
The second is in the lime industry and the demonstration is on a vertical lime. Because of the quality requirements of the finished product, many lime kilns use natural gas. A new annular ring burner will be demonstrated on an existing vertical kiln. If successful, the replication potential is large since this type of burner can be used on the existing vertical kilns of the Community.
The last project is in the cement industry and will be demonstrated on an existing cement clinker kiln. For the project, the energy saving envisaged amounts to 1,500 toe/year. With a total production of cement in the EEC of the order of 140 m tonnes, a replication of only 10% of the existing capacity could lead to energy saving of 42,000 toe/year.
For this sector, the EEC support represents almost 500,000 ECU for a total investment of 1,190,000 ECU.

d) Chemical industry

I. Introduction

The chemical industry in the Community consumed 127.4 million toe in 1979[1]; this is equivalent to 40% of the final energy consumption of all Community industry[2]. In 1975 the chemical industry accounted for only 36.5% of final industrial energy consumption[3]. One of the reasons why the chemical industry is a major energy consumer is that the energy products it uses as raw materials account for over half of all those consumed in the chemical sector. In 1979, for example, its consumption of energy raw materials (oil products, natural gas and coal) made up 54% of the total energy consumption in the chemical industry.
The chemical industry's efforts to reduce energy consumption since the first oil crisis have matched those of the rest of the industrial sector. CEFIC puts the energy savings per product unit during the period 1973-1978 at 8%[4]. Savings are probably higher in the important petrochemical sub-sector where drastic energy-saving measures have been taken and consistent investment made since the beginning of the crisis, and in the oil refining sector which is the source of most intermediate products.
As in other industrial sectors, energy savings have been secured in the chemical industry by reducing losses of materials and steam and by means of recycling and heat recovery. There is, however, now, after the remarkable progress made in the last ten years, little prospect of reducing consumption very much further by means of these techniques which have been applied to the energy required in the product manufacture.
Further substantial reductions may be made in unit energy consumption by reducing the specific losses of intermediate energy products. These can be achieved by improving process efficiency or by introducing new chemical reaction systems.

1. European Council of Chemical Manufacturers' Federations - January 1982.
2. 311.2 millions toe. (COM(81) 64 final of 23 February 1981).
3. European Council of Chemical Manufacturer's Federations - December 1980.
4. European Council of Chemical Manufacturer's Federations - July 1980.

To achieve these objectives there must be an adequate R & D basis and, once this has been established, a large volume of funds to invest in new plant.

The largest potential energy savings can of course be made in the heavy chemicals industry which consumes a vast amount of energy in product manufacture and as a raw material. The main areas are fertilizers, chlorine, soda and ethylene-derived intermediates used in the manufacture of plastics, fibres and elastomers.

There is substantial potential for energy saving in other sectors of the chemical industry, including the fine chemicals industry, but this is more difficult to quantify because of the large variety of products concerned, belonging to the following main categories :

- cleaning products for various materials (wood, leather, metals);
- adhesives and gelatines;
- explosives;
- medicines;
- cosmetics;
- pesticides;
- printing inks;
- photographic products.

It is particularly difficult to analyse the energy consumption of these categories of products and of the chemical sector as a whole because :

- the same product may be obtained from different raw materials;
- several manufacturing processes may be used to make the same product from the same raw material;
- the energy characteristics for the same process may differ according to the design of the production unit;
- the products marketed are intermediate products which will be used in further energy-consuming processes.

II. Community action

In view of the scale of the energy requirements of the chemical sector, in particular that of the heavy chemicals industry, the Commission has decided to concentrate on three projects in this sector. The Commission is also providing support for two projects concerned with oil refining which is an important source of chemical feedstock.

The total investment in these projects, of which a detailed breakdown is appended, amounts to 4.4 million ECU of which the Commission is providing 1.3 million ECU.

The first three of these projects which concern the heavy chemicals industry involve :

- a new method of manufacturing urea, which is the main constituent of nitrogen fertilizers;
- the recovery of heat from ash and gaseous emissions produced in the concentration and reduction of hematite;
- a new synthesis process for ammonium nitrate which is also used in the preparation of fertilizers.

The first project has been concluded, the second is still running and the third (which commenced at the end of last year) is scheduled to run until October 1983. The two projects in the refining sector have been successfully completed and are near the marketing phase. The first concerns the recovery of hydrocarbons in liquid effluent from refineries and the second the reduction of evaporation losses during the filling of tanks in petrol station or tankers.

As a result, three of the five projects supported by the Commission have been completed and have every chance of commercial success. The five projects will lead

to savings of 11,700 toe per year in plants and replication will give a potential of 750,000 toe per year for the Community as a whole. For total Community urea production project EE/274/75 alone could lead to savings of the order of 350,000 toe per year.
Any further Community demonstration projects in the chemical industry should concentrate on other products of the heavy chemicals industry such as ammonia, chlorine, soda, nitric and sulphuric acid and the petrochemicals sector.

e) *Glass industry*

I. Introduction

The glass industry is one of the energy-intensive industrial sectors in the Community. It can be divided into three main areas of production :
- sheet glass;
- glass bottles and containers and insulation fibres;
- more specialized glass manufacture such as laboratory and instrument glass;
- artistic glassware.

Community production in the soda silica glass (waterglas) sector is slightly more than 1 million tonnes per year and energy consumption is over 170 million m^3 gas per year.
The main measures which can be taken to achieve energy (heat) savings in the glass industry are :
(a) structural modifications to furnaces to obtain heat curves which will reduce the temperature of exhaust gases from the chamber but maintain the quality of the product;
(b) modification to furnace design and management to increase productivity (and hence reduce the specific losses) for the same chamber surface area;
(c) waste heat recovery making it possible to transfer a large proportion of the sensible heat from the furnace gases to the combustion air;
(d) improving furnace insulation;
(e) conserving heat from any intermediate products.

II. Community action

The commission has signed a contract involving a total investment of 0.8 million ECU; the Community contribution is 0.3 million ECU. This project (EE/246/80) concerns a melting furnace. The melting furnaces normally used to manufacture glass from silica sand, powdered soda and potash are "same-way" flow furnaces.
In the demonstration project the firm has used a counter-flow furnace with a daily capacity of 80 tonnes in which the feedstock is introduced on the opposite side to that of the burners. The project is extremely interesting and the experimental furnace is in use.
An experimental furnace was started up in September of last year. There have, however, been a number of hitches and the consumption of natural gas had been higher than expected (140 to 150 m^3 instead of 124 m^3 per tonne). A saving of 15% instead of 27,5% has been achieved – as compared with 171 m^3/t – but this is till of interest.
The demonstration project has been practically completed and the energy savings achieved are around half the initial target. Further measures which may not necessarily be very costly should enable this target to be reached.
The results of this experiment may be of wide application in view of the saving of 47 m^3 of natural gas per tonne achieved (which could be extended to all furnaces). This would mean a reduction of 47 million m^3 of natural gas per year.

f) *Textiles*

II. Introduction

The textiles sector has some very specific features. It is easy to define the action areas for saving heat:

- use, for air conditioning purposes, of heat emitted by textile machinery;
- rationalization of steam and air drying operations in sizing machines and similar equipment;
- recovery of heat from the smoke in the stenters (in which fuel is burned) to preheat the combustion air;
- recovery, for use in processes or services, of heat given off by stenters fed by steam or pressurized water;
- use for heating or other purposes of the heat in gaseous emissions;
- using heat pumps or self-cleansing heat exchangers to recover heat from dyeing effluents;
- possibly, the recovery of energy from waste; and
- efficient process management.

It is possible to save electricity; this depends on replacement of the textile machinery stock.

II. Community action

So far the Commission has signed two contracts in the textile sector. The investment involved was some 0.3 million ECU and financial support amounted to some 0.1 million ECU.

The first project (EE/016/79-LANEROSSI) is to recover heat in a dyebath system. The construction phase had just been completed and the measurement programme had hardly ended and the process been started up than major departures from the forecasts were noted. This was due to poor organization, which has since been remedied. The second project (EE/133/79 - SHIRLEY INST.) sets out to demonstrate how efficient automated control of dyeing operations can give significant energy savings; it is still under way.

Of the two projects which have received support only the EE/016/79 - LANEROSSI project includes an element of technological interest.

g) *Dairy industry*

I. Introduction

The energy consumption of this sector can be evaluated at about 8-10 million of toe/year. The energy intensive areas of milk processing and the manufacture of milk products are mainly:

(1) pasteurization and sterilization (heat treatment);
(2) evaporation;
(3) drying;
(4) refrigeration;
(5) transposition.

The trends towards increased efficiency on energy utilization can be summarized as follows. Heat recovery from spray driers incorporating recovery of product which is presently lost from these devices. Heat recovery from effluent streams. Increasing number of effects in evaporators. Multistage driers. New processes such as reverse osmosis and mechanical vapour recompression to improve efficiency of water removal.

The dairy industry also keeps a keen interest in the developments in the solar heating and heat pump fields where improved performance of the units could prove to be useful.
The energy savings potential can be evaluated at 20-25% of energy consumption of these industrial services, i.e. 2-2.5 million toe/year.

II. Community action

The Commission has signed two contracts in this sector.
The aid granted was some 217,360 ECU and investments 543,381 ECU.
One of the two projects uses heat pipes to recover heat from the air in powdered milk dryers (EE/008/79). The second project (EE/008/80) uses inverse osmosis to concentrate milk.
Only one of the projects (EE/008/79) has been completed. Some 430 toe has been saved: 23% of the energy consumed by the dryers. The second project (EE/008/80) is under way and the early results are encouraging.

h) Miscellaneous industries

I. Introduction

Three of the projects evaluated have been considered under this broad heading since their replication could be applied to any industry where relevant; the first applies to large gas users; the second to compressed air; the third to the utilization of mine gas in an industrial boiler.

II. Community action

In the 1st project (EE/314/79) a glass company wants to demonstrate that this energy can be recovered in an expansion motor to produce mechanical energy to drive a compressor.
The energy contained in the high pressure gas is normally lost during pressure reduction.
Industry uses almost 40% of natural gas consumed in the Community and large users are normally connected to the high pressure gas network. On the other side, gas burners require pressures of a few bars. The project is successful.
The potential for further applications concerns all large industrial gas users receiving gas at medium or high pressure.
The 2nd project (EE/167/80) has very wide applications since almost all industrial enterprises have needs for compressed air. The aim of the demonstration is to prove that part load capacity air compressors can be operated in an efficient way and save energy.
The 3rd project (EE/244/79) aims at the utilization of mine gas in a boiler whose burner had been modified. A regulation system for combustion control has also been developed. The project was successful.
The EEC support for these three projects is 240,000 ECU and the total investment is 600,000 ECU.

A.1.3. Industry Sector — Conclusions

With 27 projects receiving support, industry accounts for a large proportion of the Community's action on energy saving. Total investment amounts to some 41.5 mil lion ECU whilst 12.3 million ECU has been granted in financial support. Nine projects have been completed or are so far advanced that the results can be evaluated. The rest are not yet complete. Six of the nine have fulfilled the original forecasts of energy savings and reliability in operation. In almost all industrial subsectors the projects selected reflect the dominant technological trends.

Steel is foremost among the industries making an obvious technological effort, with many proposals of technological merit. In other sectors such as chemicals, glass, non-ferrous metals and cement, and in spite of some proposals of obvious value, the overall quality and number of projects are not commensurate with the opportunities waiting to be exploited.

There has not been much participation by other industries, probably because traditional technology is still widely used in them and this is a constraint on innovation. Another explanation might lie in the structure of the sectors concerned, which are characterized, *inter alia,* by a large number of small and medium-sized businesses which do not provide potential for major technological research and exchange little information.

Action in the steel sector must be pursued. In other industries that are big energy consumers, action should be stepped up and should demonstrate the viability and economic benefits of the following technologies in particular:

- cement: the dry process, use of derived fuels, use of waste heat, improvement of thermal insulation,
- non-ferrous metals: improvements to preheating and melting furnaces, greater use of electricity for heating, switching from batch to continuous processes;
- glass: raising furnace efficiency, waste heat as a source of low-grade heat, the recovery or elimination of heat losses in intermediate cooling;
- chemicals, particularly bulk chemicals: raising process efficiency and introduction of new chemical reaction systems;
- pulp and paper: better energy management and recovery of heat from effluents, particularly by means of heat pumps, and new paper drying techniques.

In all other industries — having regard to each one's limits and situation — Community action should continue. In addition further action by the Commission, such as the preparation of energy consumption budgets (or "balance sheets") and the dissemination of information, particularly by means of the "Energy Bus", should continue to be developed.

In dynamic sectors, and in those which have not so far been dynamic, these actions on their own cannot impart sufficient momentum to energy saving. A considerable increase in investment, dealt with in other Commission papers, is an essential precondition for achieving the Community's objectives for the efficient use of energy.

A.2. INDUSTRY : STEEL MAKING

EE/251/79 - Teksid - Italy
This project concerns the provision around a 150 th UHP electric arc furnace of an outer shell enabling the amount of air ingested by the fourth furnace orifice — and therefore the intake of fresh air — to be reduced.
The shell was completed during the first half of 1980. Unfortunately, the first measurement results show that the reduction in fresh air intake is below forecasts. However, the shell has facilitated much more efficient furnace management (higher oxygen-blowing rate, quicker run-up to full electrical load, etc.) resulting in a drop in specific consumption of about 70 kWh/t (i.e. more than twice the original prediction), together with an improvement in working conditions. Energy savings are about 4,000 toe/year. The project can therefore be considered successful in both technical and financial terms.

EE/014/80 - Estel Hoogovens - Netherlands
This project covers recovery of the heat contained in the combustion products of the blast preheaters in order to pre-heat the combustion air by means of a rotary heat exchanger.
The energy saving is 6,000 toe/year. The project is currently at an advanced development stage.

EE/074/80 - Usinor - France
In this case a system for recovering, storing and distributing LD converter gas is to be installed at the Dunkerque plant of Usinor.
The recovered gas would be consumed within the plant itself. About 100,000 toe/year could be saved. The installation work is under way.

EE/203/80 - Fulmer Research Institute - UK
The project is aimed at energy saving in the heat treatment of steels, by the use of fluidized-bed furnaces.
The energy saving has been predicted at 6 750 kJ per kg of steel treated, which is equivalent to 230 toe/year. The furnace is being installed and it should be possible to start measurements shortly.

EE/228/80 - Italtractor - Italy
This project aims at saving energy in the manufacture of finished steel stampings by replacing the traditional hardening and tempering of steel.
At the same time the simplified treatment enables at least the same quality to be achieved as for hardened and tempered products. The energy saving would be 930 toe/year. The equipment is being installed.

EE/270/80 - Maximilianhütte - Germany
Project for recovering converter gas at the Maximilianhütte steelworks in Rosenberg. The technology used is not the same as in the Usinor project.
In this case it forms part of a more general energy-saving programme and of the rationalization of the Rosenberg plant. Work has not yet begun.
An energy saving of 6,500 toe/year is expected.

EE/034/81 - British Steel Corporation - UK
The project involves pre-heating of the scrap charge for a 110 t electric arc furnace by recovering the heat extracted from the fourth exhaust orifice from the furnace.
The foreseeable energy saving is 43 kWh/t of steel produced, which is equivalent to 990 toe/year. Installation is virtually complete and the measurements will begin shortly.

EE/246/81 - Thyssen - Germany
In order to extract energy from the gas pressure in the furnace throat, the project envisages the installation of a four-stage by-pass turbine having variable guide vanes in the first-stage stator; these regulate the blast-furnace back pressure continuously.
The turbines will drive two 13,000 kW generators, thus yielding a primary energy saving estimated at about 27,000 toe/year. The turbo-alternator set is almost ready and the measurement programme should begin soon.

EE/253/81 - Danieli - Italy
Here the scrap charge for a 45 t electric furnace is to be pre-heated by the continuous heat flux in the hot gas exhausted from the fourth furnace orifice.
In the Danieli project, as opposed to project EE/034/31, the hot combustion products will transfer their heat through a surface-type heat exchanger to an air flow which will heat the scrap.
An energy saving of about 50 kWh/t of steel produced has been forecast; this is equivalent to 1,500 toe/year. The installation is at the project stage.

INDUSTRY : NON FERROUS METALS

EE/147/79 - Electricity Council Research Center - UK
Improved Design of an Electric Induction Billet Heater.

This project demonstrates an increased efficiency electric induction billet pre-heater by better utilisation of the available copper in the windings. Two applications are envisaged, one for aluminium billets (2 t/hour) and one for copper alloys. (2.1 t/hour). Energy saving in terms of primary energy shall be 526 toe/year. Predicted results are being realised on one of the demonstration models, the second one being under construction.

EE/251/80 - Norddeutsche Affinerie - D
Copper Melting Shaft Furnace for Refined Copper Anode Production.
This project demonstrates the energy efficiency advantages of the shaft furnace over the more conventional reverberatory type. The throughpout is 60 t/hour and the energy saving envisaged corresponds to 5,000 toe/year. This project involves belgian and german companies having collaborated in R & D efforts and decided to finance jointly the investment for demonstration.

The payback of almost 8 years would normally be unacceptable. However, using only the furnace equipment costs this reduces to a more realistic 5 years.

EE/087/81 - Electricity Council Research Center - UK
Improved Design of an Electric Induction Furnace for melting Aluminium.
This project demonstrates a new design of electric induction furnace whereby refinements in the channel and throat of the furnace will produce an increased power density and a vigorous stirring action in the molten metal. This should give rise to reduced metal loss and increased efficiency. A reduced metal loss of 1% represents 700 kWh/t and energy saving of 743 kWh/t should bring total energy saving of 1,443 kWh/t or 1,000 toe/year. The envisaged payback period of 1.6 years is good. The project is still in the design stage so no operating experience is known.

INDUSTRY : CEMENT, BUILDINGS MATERIALS (BRICKS, LIME)

EE/001/80 - Gebrüder Löhlein - D
Conversion of Brick Tunnel Kiln to Pulverised Solid Fuel Firing.
This project claims substantial energy savings (60 %) by converting an oil fired kiln to solid fuel firing i.e. 1,310 toe/year. Operating experience to date has revealed a higher average specific energy consumption than was first envisaged.

There is certainly a need to spread information regarding the solid fuel firing of brick kilns to encourage organisations to use pulverised fuel technology in this field.

It is a pity that the projected fuel savings were based on work carried out on another kiln. The rue energy savings can only be known by analysis of past specific fuel consumption figures for this kiln. Despite these facts, the energy saving achieved are above 40 %.

EE/094/80 - Saueriandische Kalk Industrie - D
Improvement in Specific Energy Consumption on Vertical Lime Kilns by use of Ring Burner System.
This project demonstrates an improved burner system for vertical lime kilns. The system is claimed to reduce the specific energy consumption and improve product quality by improving combustion and heat distribution within the firing zone. The energy saving envisaged are 1,080 toe/year.

If proved successful, the system could be readly replicated on other gas fired vertical lime kilns.

EE/171/80 - Creusot Loire Entreprises - F
Rotary Cooler with Peripheral Blowing on a Cement Clinker Kiln.
This project demonstrates an improved cooler for a cement clinker rotary kiln to produce clinker which is 300°C lower than the conventional grate cooler. Energy saving envisaged are 1,750 toe/year.

The payback period of 3.25 years should encourage other users of such kilns to use the equipment. However, the maintenance costs charged against this project appear to be rather high and a reduction here would increase the commercial viability of the plant.

INDUSTRY : CHEMICALS

EE/274/79 - Fertimont (Montedison) - Italy

The demonstration project is located in a plan producing urea — one of the main components of nitrogen fertilizers.

The existing process consists of combining ammonia and carbon dioxide. Its efficiency is low and partly responsible for the high energy consumption. The project aims at modifying the unit in order to recycle the unreacted raw materials and thereby to increase reaction efficiency to 55-75%. This increase in efficiency would yield an energy saving of about 6,000 toe/year. The programme has been delayed by longer delivery periods for the equipment. It was completed at the end of the first quarter of 1982 and the final report is in preparation.

EE/125/80 - Elf Aquitaine - France

The object of the demonstration is a device enabling liquid effluent from oil refineries to be concentrated, thereby reducing consumption of the energy needed to separate the water from the hydrocarbons.

It involves a cylinder coated with a film enabling hydrocarbons to be separated out of water suspensions. The project has been completed and has enabled 2,500 toe to be recovered from the refineries where it has been installed. The contractual aim has thus been achieved and the project is a commercial success.

EE/129/80 - Agip Petroli - Italy

When filling station reservoirs or delivery lorry tanks are filled the vapours left over from the previous load are vented to atmosphere.

In order to avoid hydrocarbon losses and pollution a condenser, followed by a refrigerated condenser, is located at one of the tank orifices. The residual vapours are thus recovered in liquid form. The project has been completed. Although the amount of hydrocarbons recovered is less than the target owing to the climatic conditions during the demonstration, the project has a good chance of commercial success.

EE/224/80 - Solmine - Italy

The aim of the project is to utilize the waste heat from the reduction process in the manufacture of magnetite sinter.

The project is in two sections :

(a) Recovery of heat from the sinter by means of a fluidized-bed cooler.

(b) Recovery of heat from the reduction of gases via incineration and an economiser.

The waste heat will be used to pre-heat the boiler feed water. The energy saving expected is 1,400 toe/year. The project is at the design stage.

EE/022/81 - Union Chimique - Belgium

This is a new process for synthesizing ammonium nitrate which requires no external energy source since it generates enough heat to provide steam which can be used in other processes.

This process also yields a higher yield and enables liquid effluents of sufficient purity to be produced which can either be re-used or discharged directly. One energy saving of 260 toe/year is expected. The general application of the process would enable an energy saving of about 100,000 toe/year to be made at Community level. The programme began on 1 January 1981 and should end on 15 September 1983.

Glass industry

EE/246/80 – AKZO CHEMIE B.V. – NL

A countercurrent glass-melting furnace with heat recovery for sodium glass.

The melting furnaces usually used to manufacture glass from siliceous sand and sodium and potassium powder are of the «undirectional flow» type in that raw materials are charged on the same side as the burners and the convection currents which develop at the bottom of the melt flow in the same direction as the combustion products.

Under the demonstration project, the firm has built a countercurrent furnace which is charged on the opposite side to the burners so that the convection currents in the melt flow in the opposite direction to those in ordinary furnaces. The experimental furnace which has a production capacity of 80 tonnes a day has been fitted with a heat recovery system which heats the combustion air with the residual heat from the flue gases, which are then discharged at only 600°C. When designing the system, the firm was expecting these modifications to produce a dramatic reduction in fuel consumption from 171 m^3 NTP of natural gas per tonne – which is the consumption of an ordinary 80 tonne-a-day unidirectionnal furnace – to 124 m^3 NTP per tonne, a saving of 27,5% which is equivalent to some 350 toe a year.
The experimental furnace began to operate in September 1981 but unfortunately there were a number of problems and the consumption of natural gas is therefore considerably higher than expected: between 140 and 150 m^3 NTP per tonne instead of 124 m^3 NTP per tonne. This is still a saving of 15% compared with the original consumption of 171 m^3 NTP per tonne, which is by no means negligible, although not as high as 27,5%.
Basically, therefore, the project ended up achieving 45% of the success originally expected. Additional modifications – which would not necessarily be very expensive – could bring this success rate up to 85 or 90%.
The significance of these results is undoubtedly of very widespread benefit if one considers that just over 1 million tonnes of glass is produced in the Member States of the Community each year. Cutting natural gas consumption from 171 to 124 m^3 NTP per tonne (i.e. by 47 m^3 NTP a tonne) – the expected saving which can be applied roughly to all furnaces – would reduce consumption of natural gas by 47 million m^3 a year, which is equivalent to some 40,000 toe a year. Even the saving of 26 m^3 NTP per tonne already obtained would be equivalent to 22,000 toe a year.

Industry: textiles

EE/016/79 – Lanerossi – Italy

The aim of the Lanerossi project carried out on existing textile dyeing plant in their Schio factory was intended to demonstrate the technical feasibility and energy efficiency of a modification enabling a large proportion of the cooling and condensation water to be recovered as a result of a modified layout for the bath heating and cooling circuits.
The modification consists of separating the heating and cooling circuits and giving each its own heat exchanger, and rearranging the cooling circuit to accept both softened and hard water. With regard to the ratio "kg of bath water to kg of cloth" and to the techniques adopted: it is planned to recover 73,000 m^3/year of soft water at an average temperature of 45°C and 22,600 m^3/year of demineralized (distilled) water at 105°C, i.e. an estimated energy saving of 444 toe/year.
The measurements are under way but are behind schedule owing to technical problems which have been dealt with in the meantime.
The initial measurements revealed very wide divergences in the amounts of water and condensate recovered as compared with the initial forecasts. The causes (coil porosity, valve life) have been pinpointed and eradicated. Consequently, the final results should coincide with the initial forecasts.

EE/133/79 – The Shirley Institute – UK

Project to demonstrate that very strict process control in the textile industry may enable management procedures to be formulated which could yield considerable energy savings.
The programme is under way in a textile dyeing plant having an annual cloth treatment capacity of about 4,000 t. Overall energy consumption would be about 270 TJ (6,500 toe/year) of which 77% consists of fuel oil, 17% of gaseous fuels (methane and propane) and 6% of electricity.
The aim of the project is to reduce the above-mentioned consumption figures by 10% at the end of the demonstration period (equivalent to about 650 toe/year) by installing suitable measuring instruments, analysing the data recorded and, finally, proposing on this basis suitable modification either to the installation or to the running thereof.
The project it at advanced stage and the tests carried out so far foster the hope that the targets will be met.

Industry : dairy industry

EE/008/79 – Carbery Milk Products Ltd – IRL
This project has been installed and is operating in the premises of Carbery Milk Products Ltd., Ireland.
The project is now complete and the first set of tests have been carried out. The results show that for similar production runs, 23% of the primary energy input was saved on the production run with the heat recovery equipment installed. This is a little better than first estimates.
The testing organisations have carried out more work to finalise the savings in energy over long term operating and have performed another series of tests with the variables being maintained as constant as is practically possible. The results of these tests have not yet been published, but they are satisfactory.
In conclusion, the project has yielded positive results, the energy savings being estimated at about 430 toe/year.

EE/008/80 – Cooperative Zuivelfabriek en Melkinrichting «DE EENDRACHT» W.A. – NL
This project has been raised to demonstrate the reverse osmosis technique as a pre-concentration unit to an evaporator.
The aim was to increase the solids content of the skimmed milk form 6 – 8% to 18% by removing over 50% of the water in the original feed stock. The energy savings envisaged correspond to 330 toe/year.
The project is not yet completed but first tests have proved encouraging. The main energy saving from this project is claimed to be in the transportation of the end product from the pre-concentration plant to the evaporators. This would no necessarily be realised where both units are ont the same site. The financial submission on the contract needs further examination since the cost of running the equipment appear to be higher than the value of energy saved.

Industry : miscellaneous

EE/244/79 – Joseph Crosfield & Sons Ltd – UK
The project covers the use of gas continuously extracted from coal mines which, normally, is vented to atmosphere. The existing boilers have been modified so that all the coal gas extracted from the mine – and, if need be, natural gas and heating oil – can be used.
The measurements carried out over 12 months have been extremely convincing. The new three-fuel burner and the control system have proved that they operate excellently and are reliable. Boiler ouput has remained virtually unchanged, thus enabling fuel oil and natural gas consumption to be reduced by about 22,000 toe/year.

EE/314/79 – Hermann Heye – Germany
This project demonstrates the use of mechanical energy made available by the expansion of natural gas from its supply pressure of 50 bar to its working pressure of 2 bar.
The energy is used to drive a screw type air compressor and corresponds to an energy production of 806 toe/year. The equipment installed has proved to be cost effective but its use will of course be limited to areas where gas is supplied at high pressure.

EE/167/80 – Compair Industrial Ltd. – UK
This project demonstrates a device by which screw compressors can be operated at part load more efficiently by utilising a two speed drive system.
The energy saving envisaged are 20 toe/year in primary energy. The project has reached the prototype build stage and first estimates of capital costs have been justified. This scheme should prove to be commercially viable when offered as an extra to the company's existing compressor range. Potential for replication is extremely good.

ANNEX B

ALUMINIUM ENERGY AUDIT

In 1980, the EEC Aluminium Industry produced over 2 M.t. of primary aluminium and over 1 M.t. of secondary aluminium.

Energy consumption was 11 Mtoe/yr and energy savings of 1 Mtoe were obtained between 1976 and 1979 by improvement in specific energy use.

The breakdown of savings by activity is documented for alumina plants, smelter hot metal, smelter casting plants, fabricating remelts, hot rolling ,cold rolling and finishing, extrusion, foil plants, secondary smelters and casting. Changes in specific energy use were from - 1.7% in foil plants up to 23.8% in smelter casting plants.

In 130 pages, the Energy Audit analyses the energy sources, the collection and distribution of national data, including individual results, discusses of ways to increase energy efficiency and outlines the industrial applications of properties of aluminium and its alloys and stresses the role of recycling as an additional basis for energy saving.

POSSIBILITIES FOR INTERNATIONAL COOPERATION IN THE FIELD OF RATIONAL USE OF ENERGY

Ulises Ramirez Olmos
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1. INTERNATIONAL COOPERATION

The dialogue on international cooperaton between the industrialized and the Third World countries dates back to the Conference on International Economic Cooperation (CIEC), held in Paris is between 1975 and 1977. Although this Conference represented neither the beginning nor the end of that dialogue, it did, however, constitute a forum in which the problems could be examined more in depth and in which many of them could be identified.

It also helped to focus world attention particularly on the problems of aid for the development of raw material exports, the problem of foreign debt, and in general the disparity of wealth between the Western developed countries and the developing nations. Just to mention a few figures, the South, which brings together 70% of the world's population, in 1977 accounted for 19% of the total gross product, 20% of the trade and investment, 7% of the industry and less than 1% of the research and services.

The specific demands presented by the developing countries were related particularly to the following: adoption of the integrated trade program of the UNCTAD; energy conservation, development and financing; protection of the buying power or revenues from exports and of other assets; payback and reorganization of debts; adoption by the developed countries of the goal of official aid to development of 0.7% of the gross domestic product; access to the money markets of the developed world; development of infrastructure; full implementation of the "Lima Declaration and Plan of Action", which requests an increase in the developing countries' share of the world's total industrial production so as to arive at a minimum of 25% by the year 2000; greater food production in the developing countries, assured food supplies and aid; transfer of technology through approved foreign investments; and financial and monetary reforms at the international level, i.e., IMF and IBRD resources, reallocation of special resource rights and greater access to these resources for the developing countries.

While the demands were not satisfied, they were suitably represented in the resolution on International Cooperation and Development, adopted by the Seventh Special Session of the United Nations General Assembly in September 1975.

In this resolution, all countries were invited to unite in the search for solutions to the world's problems, particularly in the following areas: international trade, transfer of real resources to the developing countries, internationl monetary reforms, science and technology, industrialization, food and agriculture, and restructuring of the economic and social sectors of the United Nations.

In viewing international cooperation from this perspective, we can conclude that the cooperation relative to the energy component is merely one part of the problem, for which reason it should be dealt with in the essence and spirit of the demands laid out at the time by the countries in the Third World.

2. COOPERATION WITHIN THE FRAMEWORK OF OLADE

The industrial growth of Latin America has hinged upon the intensive use of hydrocarbons as a commercial energy source. In the region, oil-importing and exporting countries exist together and in one way or another they have sustained the development style reflecting the process generated after the Second World War, as a result of the reconstruction of Europe and Japan.

From the start, Latin America has been aware of the importance of non-renewable sources of energy both as the cornerstone of development for the oil-exporting countries, as well as a fundamental imput towards attaining higher standards of living and comfort in the oil-importing countries. Furthermore, by virtue of the fact that they are exporters of raw materials, all have suffered first-hand from the adverse effects of market fluctuations, especially as regards demand and low prices.

Prior to the North-South Dialogue, our countries have already taken the first steps to activate cooperation in the area of energy, so that before the creation of OLADE in 1973, ARPEL, which groups the State oil companies of Latin America, and CIER, which joins the efforts of the electric light and power companies of South America, already existed. Likewise, in Central America, steps were being taken towards electrical interconnections.

In 1981, OLADE approved the Latin American Energy Cooperation Program (PLACE), within objectives, policies and programs were defined for the regional energy strategy up to the year 2000. The Ministers of Energy decided on that occasion that energy should be tied to social and economic development so that its production and its demand would stimulate the development of capital goods industries. Likewise, it was decided that it would be necessary to expand and diversify the energy supply in order that the structure of energy production and use could be modified.

2.1. THE ENERGY SITUATION OF LATIN AMERICA AND THE CARIBBEAN

The Latin American region produces more than it consumes, so that in 1970, of a total production of 432 million TOE, 51.4% was earmarked for exportation. Although the 1980 production was 534 million TOE, almost 24% higher than the 1970 figure, exports dropped to 34.5% of total production as a consequence of the region's greater needs - which demanded a consumption growth rate of 5.4% annually - and due to the lower growth rate for production (see Table 1).

Energy production is based primarily on hydrocarbons, which account for 72% of the 1980 total, as opposed to 78% in 1978, as a result of the decline in production between 1970 and 1976.

As for energy consumption, it too is concentrated on hydrocarbons, whose participation increased from 45.3% in 1970 to 46.4% in 1979. Hydroenergy went from 13.7% in 1970 to 16.2% in 1980, and the use of firewood fell from 20.1% to 14.6% (see Table 2).

Latin America is rich in energy sources, and its availability of conventional sources, without including biomass and solar and wind energy, makes it possible to look to the future with optimism. The proven reserves are considerable and amount to 51.175 million TOE, of which 49.8% corresponds to hydroenergy, followed by oil with 21.6%, coal with 11.9%, natural gas with 13.5% and finally, nuclear and geothermal energy with 3.2% between the two (see Table 3).

Unlike natural gas and oil, 80% of the reserves of which are concentrated in Mexico and Venezuela, the hydroelectric potential is characterized by a better distribution among the regional countries.

From the foregoing, it can be discerned that no suitable ratio exists between energy reserves and consumption, for which reason the expansion and diversification of the supply entails broad modifications in the structure of the production and use of energy, which inevitably transcends the technical and economic dimensions, which are complex in themselves.

Together with the accelerated development of all types of energy sources, the rational use of energy rests on the application of effective measures for its conservation and the accomplishment of greater efficiency in use.

2.2 ENERGY PROSPECTS FOR LATIN AMERICA AND THE CARIBBEAN

The outlook for energy demand for the year 2000 was recently reviewed by OLADE, taking into account the new critical situation of the world economy, and using the energy balances for the 1970-1981 period. It is worthwhile to note that the region has available a common OLADE methodology for preparing the balances and it has been used by 22 countries. For the forecast, one single population growth rate of 2.21%

inter-annually was used for 1985-2000, on the basis of demographic estimates made by ECLA. Future economic development for Latin America and the Caribbean is based on the recent behaviour of our economy, which implies a low economic growth rate between 1980 and 1990, of an average 3.8%. This should rise to 6% annually during the 1980-2000 period. If such low levels of growth are maintained, we will find ourselves in deep trouble in terms of socio-political problems.

The results of this study indicate the following: (See Tables 4 and 5 and Figures 1 and 2.):

1. Primary energy consumption for the year 2000 will reach a level of 977 milion TOE, and final consumption is estimated as being on the order of 657 million TOE.

2. Final demand for derivatives will drop slightly from 55.9% in 1980 to 54.6% in the year 2000. Nevertheless, in absolute terms, consumption will rise by a factor of 2.5, to 359 million TOE (6.9 million BOE per day).

3. Direct firewood consumption will drop substantially, from 19.7% to 5.3% over the 1980-2000 period, whereas charcoal will increase from 1.8% to 2.3%.

4. Electricity will continue its upward trend, going from 9.2% in 1980 to 15.4% in the year 2000. In this regard, it is important to underscore the growing participation of hydroelectricity as a primary source of energy which will go from 15.8% in 1980 to 22.4% in the year 2000.

5. Natural gas will increase its participation from 8.8% in 1980 to 15% in the year 2000.

6. The aforementioned changes reflect the growing importance of commercial forms of energy, as opposed to non-commercial ones such as firewood, charcoal and plant and animal fuels. It is estimated that commercial energy will rise from 77.1% to 91.5% over the same period.

The aforesaid points to the fact that during the next 20 years the energy supply of Latin America will continue to rely on hydrocarbons, particularly oil, despite the measures taken towards the implementation of other sources, mainly hydropower, taken that Latin America and the Caribbean could be considered the area for water, coal and geothermal energy.

2.3 POLICY GUIDELINES

In order to achieve an orderly and coherent transition to a greater energy, plurality involving the more rational use of energy, in 1981 the OLADE Ministers also agreed to set the following policy guidelines:

1. To develop, in the shortest term possible, a strategic overview of Latin American energy development, as an indispensable starting point for effective regional programming, which should be launched with work geared to elaborating national energy programs on the basis of common methodologies. Along these lines, various national energy programs and energy balances elaborated by OLADE have been made available. National energy plans are a necessary pre-requisite to a broader vision of future regional energy problems, permitting fuller cooperation.

2. To spur unified and on-going regional action in international forums and agencies, and before other countries, etc, for negotiation and cooperation activities in the field of energy.

3. To accelerate well-grounded knowledge about energy resources, where this is understood to be a continuous task of review and updating basic to national and regional programming of energy development.

4. To promote systematic efforts at energy economy, aimed at reducing energy consumption in wasteful sectors, without affecting general economic growth. Efforts geared to more careful energy use should be put into practice, and in many cases this would entail no capital costs. To this end, there is expertise accumulted by some countries within the region; and this should be rapidly disseminated and assessed at the regional level. Along the same vein, one can speak

of the more widespread application of already-known or recently-introduced technologies related to enhanced recovery of industrial wastes, changes in industrial processes, or modifications in the design of inputs and capital goods. All of this gamut of measures, oriented towards increasing conservation and energy savings, should be the object of maximum attention and study; and its generalized implementation should constitute a top priority.

5. To strengthen and expand the scientific and technical capacity so that the region will be able:

   a) to survey the inventory of technical and economic profiles for technologies available inside and outside the region for the incorporation of new, renewabale and non-renewable sources of energy and for their broad diffusion among the diverse institutions and regional producers and consumers;

   b) to advance in the creation, development and adaptation of technologies for tapping new sources;

   c) to organize demonstration programs on the production and use of new sources;

   d) to establish on-going mechanisms for the intraregional transfer of technology; and

   e) to follow up on research and technological development which may occur outside the region, for the purpose of keeping up-to-date the possibilities for selecting technologies more suitable for the region's own socio-economic conditions, particularly due to tne growing relative weight that nuclear energy may acquire in the long range within the world energy balance, and due to the fact that it is foreseeable a have a drop in real costs for the construction of standard plants and thus it is imperative for the region's countries to have in-depth follow-up on reseach and development of such technology, both in the field of electric power generation as well as systems for assured supplies and environmental protection.

6. To give an urgent push to prospecting and exploration tasks in oil deposits, where this is conceived as an undertaking which, without jeopardizing State sovereignty, should be essential and integrally regional. Formulas should be stressed to link regional efforts in this respect, for the purpose of strengthening the region's energy security. Cooperation in this regard would lead to strengthening the Latin American energy market. Particularly, the degree of security of the regional energy supply should be increased through the design of emergency programs and progressive increases in regional hydrocarbon supplies, in keeping with the respective national programs.

7. To foster the utilization of shared natural resources by developing bilateral and/or multinational projects benefitting countries having common borders, within the framework of the national sovereignty of each State.

8. To spur the development of a Latin American industry of capital goods and equipment for the energy sector, which could respond dynamically to the major objectives involved in the energy transition underway in the region. The requirements derived from the rural development programs which seek the massive implementation of decentralized systems of energy production and use should specifically be contemplated.

9. To implement mechanisms permitting energy costs to be minimized through the rationalization of processing, transportation, storage and distribution of the regional energy resources.

10. To bolster the ordering of energy commercialization systems through the intensification of direct bargaining between exporting and importing countries so that, without jeopardizing the revenues of the former, the latter will be able to benefit from the margins of trade available to private enterprise in this area.

11. To introduce training of the teams necessary for implementing each one of the specific programs that can lead to the attainment of the region's energy objectives.

12. To propitiate an increase in scientific, technological and financial resources from the OLADE Member States, other countries, groups of countries and internatonal organisations; and to earmark these for top priority PLACE projects. These resources will be complementary to those available from within the region, and their procurement will in no case be indiscriminate or foreign to the purposes of the program, so as to avoid jeopardizing national sovereignty or working against regional interests.

13. To foster the rise of institutions, attitudes and social practices that can underwrite the energy transition.

These guidelines constitute an effective Latin American response to international cooperation, based mainly on inter-regional cooperation initiatives in order to have more far-reaching programs of broader scope.

3. SPECIFIC COOPERATION ACTIVITIES FOR RATIONAL USE OF ENERGY

It seems obvious, then, that in the face of the overwhelming task required to close the existing gap between Latin America and the industrialized world, it becomes necessary to reinforce internatonal cooperation within the postulates set forth in the North-South Dialogue. Bearing in mind that these talks are now in progress within the framework of the United Nations, it corresponds to sectoral and regional organizations to spur on specific activities that can provide a basis for viable aid of greater transcendency.

An ambitious program of rational energy use for Latin America and the Caribbean would yield the following results, assuming a low elasticity of 1.26 (corresponding to the 1970's) and of 1.0 for the year 2000.

YEAR	FINAL ENERGY SAVINGS (10^6 TOE)	SAVINGS (US$ x 106)
1985	53	10,700
1990	90	18,300
2000	174	35,300

While these figures are plausible, but not possible - since this effort would entail rigorous conservation measures in the transportaion, industrial, services and residential sectors, with their consequent socio-economic and political effects - they do indicate the broad possibilities that we have in Latin America and the Caribbean for the rational use of energy to constitute a new source. The challenge laid out in these terms proves interesting; and for this purpose, intense mobilization of internaional cooperation is required in the fields of technical cooperation, investment and trade.

3.1 TECHNICAL COOPERATION

The measures relative to energy conservation in industry can be of two kinds, one being the maintenance of relatively lower capital expenses and the other, improvements of a technological nature, with long-term development and the consequent capital requirements. In order to manage the implementation of a conservation program for the two approaches, traditional attitudes must be overcome, on the one hand, and on the other hand, problems of a strictly technical nature, so that if an attempt is to be made to successfully apply measures geared to energy conservation in the industrial sector, it is imperative to create mechanisms for consciousness-raising and training that can assure compliance. The existence of complementary experiences and capabilities in this field arouses great interest. It would also be worthwhile to receive cooperation aimed at stimulating measures for rational energy use in the industrial sector so as to permit the development of capital goods and services in our countries.

3.2. INVESTMENTS

Even though in a first stage of the energy conservation programs the capital requirements will not be so demanding, we have found that, due to the economic crisis faced by the regional countries, it becomes necessary to mobilize grants or soft funds to speed up this process, taking into account that in the first stage the conservation program will tend to include actions such as the following: more careful management of plants; adjustments in heating, ventilation and lighting, where suitable furnaces and boiler control can represent an important contribution; thermal insulation, etc.

In this first stage, mechanisms can be sought so that, through OLADE, international assistance can come to complement regional action in this area. In a second stage, wherein technological changes will usually entail sizeable investments, with the use of more sophisticated control systems, as well as the installation of new equipment and processes, these capital requirements enter into competition with other demands for capital, related, for instance, to an increase in the levels of national energy production. This means that in this stage the most urgently-needed sums must be mobilized in the form of soft or contingency loans that will make it possible to attain the levels of development required by Latin America.

3.3 TRADE

The flow of trade that could be established by programs of rational energy use in Latin America must be of mutual benefit, in the sense that the terms of trade should not deteriorate; and this demands that the trade growing out of this energy activity must be tied to other commercial activities.

In conclusion, it becomes necessary to continue with, and to intensity, the efforts of rational use of energy in industry, because this can lead us to an important recovery for our economies, with tangible positive effects for the world as a whole.

Table 1

ENERGY TRENDS AND CONSUMPTION IN LATIN AMERICA
(toe x 10^6)

	1970	1975		1979		1980	
PRODUCTION	432	422	0.4	501	5.9	534	6.6
EXPORTS	222	161	5.2	171	2.0	184	7.6
IMPORTS	56	88	7.8	93	1.9	86	-7.5
TOTAL PRIMARY ENERGY CONSUMPTION	234	330	6.4	398	6.4	411	3.3
FINAL ENERGY DEMAND	150	216	6.3	251	5.1	254	1.2

Table 2

ENERGY CONSUMPTION BY SOURCES
(toe x 10^6)

	1970	%	1976	%	1979	%	1980	%
COAL	8	3.4	10	3.0	14	3.5	15	3.6
WOOD	47	20.1	56	17.0	58	14.6	60	14.6
OTHERS	8	3.4	12	3.6	16	4.0	17	4.1
OIL	106	45.3	158	47.9	190	47.6	192	46.6
HYDRO	32	13.7	48	14.6	60	15.1	67	16.2
GAS	33	41.1	45	13.6	59	14.8	60	14.6
GEOTHERMAL		-	- 0.3	0.1	0.6	0.2	0.5	0.1
FOSSIL FUELS		-	- 0.6	0.2	0.7	0.2	0.7	0.2
TOTAL	234	100.0	329.9	100.0	398.3	100.0	411	100.0

Table 3

ENERGY RESERVES
(toe x 10^6)

		%
OIL	110.71	21.6
GAS	69.00	13.5
HYDRO	255.60	49.8
COAL	61.26	11.9
NUCLEAR	14.75	2.9
GEOTHERMAL	1.43	0.3
TOTAL	512.75	100.0

TABLE 4

ENERGY SAVING POTENTIAL
(FINAL ENERGY DEMAND)

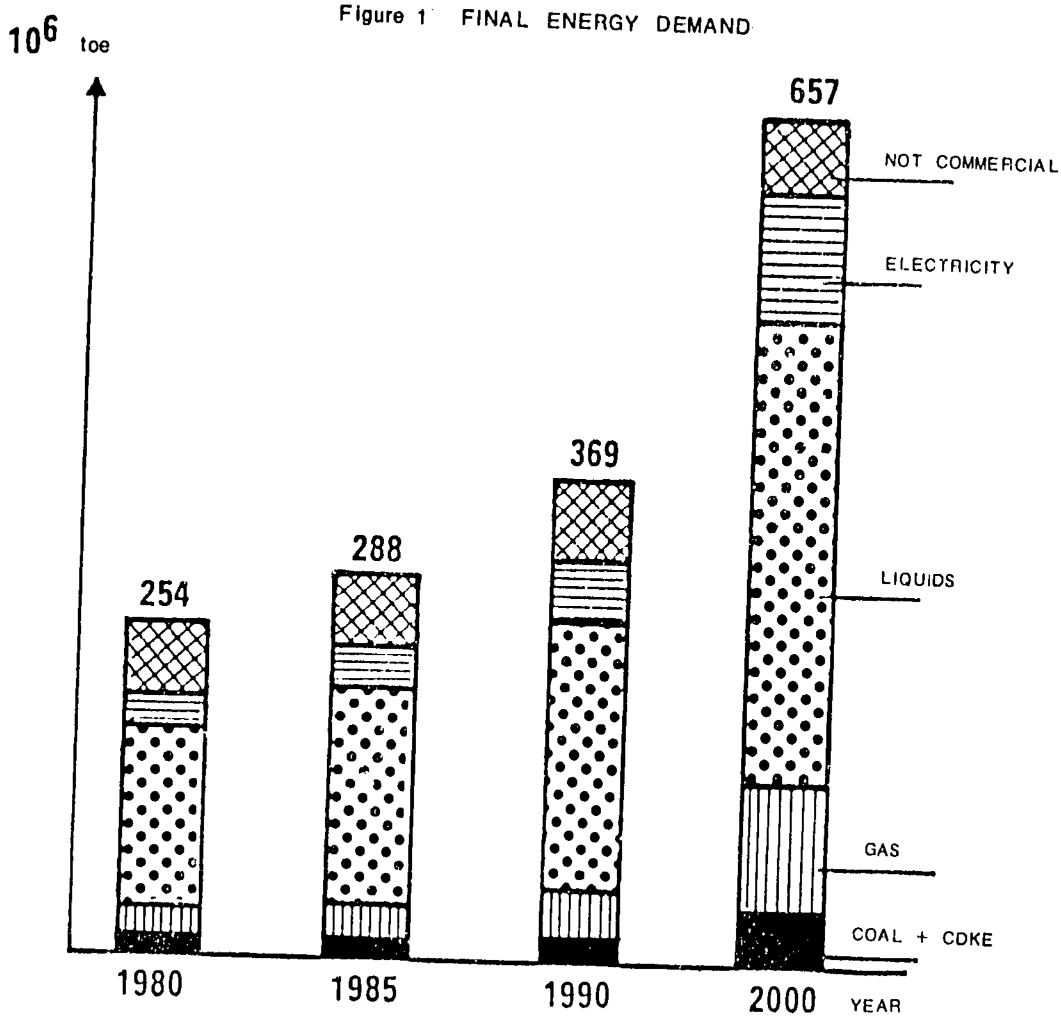
YEAR	SAVINGS (10^6 toe)	SAVINGS (10^6 US$)
1985	53	10.700
1990	90	18.300
2000	174	35.300

Table 5

ENERGY DEMAND PROJECTION
(10^6 toe)

	1980	1985	1990	2000
PRIMARY ENERGY CONSUMPTION	376	419	541	977
FINAL ENERGY DEMAND	254	288	369	657

Figure 1 FINAL ENERGY DEMAND



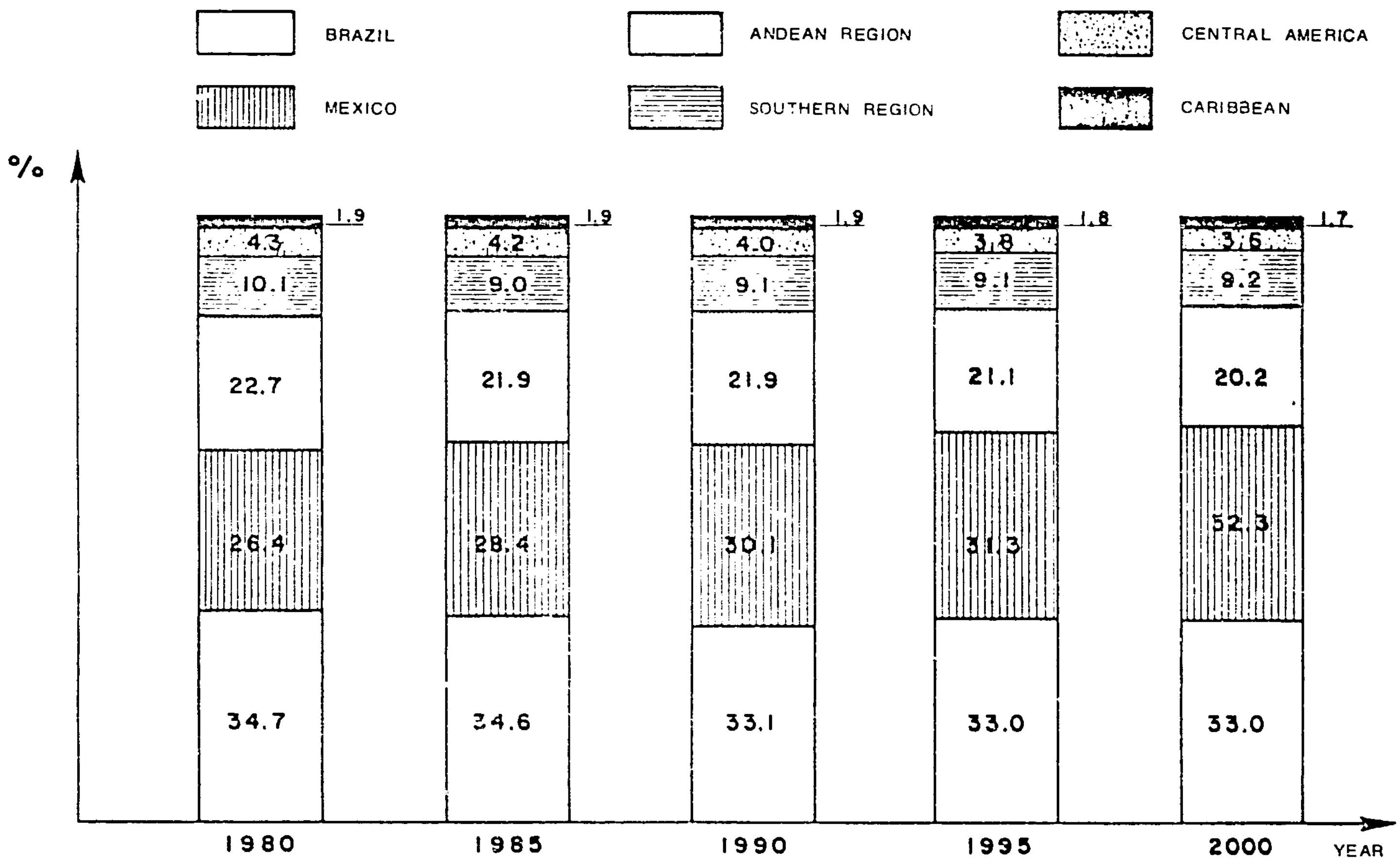

BRAZIL
ANDEAN REGION
CENTRAL AMERICA
MEXICO
SOUTHERN REGION
CARIBBEAN
%
1.9
4.3
10.1
22.7
26.4
34.7
1.9
4.2
9.0
21.9
28.4
34.6
1.9
4.0
9.1
21.9
30.1
33.1
1.8
3.8
9.1
21.1
31.3
33.0
1.7
3.6
9.2
20.2
32.3
33.0
1980
1985
1990
1995
2000
YEAR

Figure 2

POSSIBILITIES FOR INTERNATIONAL CO-OPERATION IN THE FIELD OF RATIONAL USE OF ENERGY

J. Wallace Hopkins
Deputy Executive Director
International Energy Agency

We have seen, throughout this Seminar, vivid illustrations of how gatherings of this type can concentrate experience gained in many parts of the world, and bring it to bear on a given subject. I would like now to mention a number of other subjects and techniques which could also produce satisfactory results for increasing international co-operation.

I. DATA AND INFORMATION FLOWS

- Work is clearly required all around the world to improve and expand information in the following areas:

(1) Statistical, including energy supply and demand flows and balances.
(2) Technical, including information on scientific, technological, economic and sociological aspects of new ideas.
(3) Institutional information, i.e. identifying which organisations are doing what in the various areas of energy development and conservation.
(4) Research and development information, including efforts to conserve potential energy resources and potential energy demand state of the art reports on new technologies, including costing and maintenance and labour requirements.

- Many obstacles exist in the area of information and data due to lack of co-ordination, inconsistent statistical reporting and the use of different methodologies used for data bases.

- A number of UN organisations are involved in data collection and co-ordination to overcome these difficulties.

- Recently the International Energy Agency, various UN bodies, the World Bank, the Asian Development Bank, UN regional organisations such as CEPAL and ESCAP, and OLADE, along with various national administrations and private sources, have been working in co-operation to develop an integrated and co-ordinated energy data base for 40 or so developing countries. This project should be completed in the autumn of this year.

- This is an excellent example of international co-operation in which an important project was identified, was started with minimal resources and through close and continuous communications has grown to include the many organisations named in a loosely organised network, and which will be completed requiring little if any outside resources.

II. PLANNING AND POLICY DEVELOPMENT FOLLOWS DIRECTLY FROM BETTER DATA

- Energy policy and planning at the national level are key elements for development and use of energy resources compatible with economic development.

- Need to co-ordinate energy planning to take into account the relevant elements of economic development plans, social development plans, popular trends, investment requirements and management of natural resources.

- There is a growing need also to relate national needs, resources and plans to the context of regional and global supply and demand requirements.

Examples of Co-operation

- Among the sponsors of this Seminar, (the IEA is an example of broad international co-operation), OLADE and the EEC are examples of regional co-operation in the geographic sense.

- Each of these has been able, with the help of a central Secretariat, to encourage the collection and dissemination of information; to co-ordinate objectives and develop understanding about energy on an international basis; and to influence policies of member countries within the international context represented by the group as a whole.

- Other regional organisations with similar characteristics in other parts of the world could achieve similar results, and could also generate co-operation among organisations such as that which has been achieved between OLADE, the EEC and the IEA.

III. EDUCATION AND TRAINING

Substantive Issues

- Expanded educational and training facilities should be available for government policy makers; planners; for enterprise managers; for technological specialists; and for the general public.

- Specialized training facilities could be addressed to the following areas: engineering, science and technology, social sciences and resource planning.

- The types of education and training will vary according to country, but may include established institutions such as university programmes, development of new and specific specialized programmes, or the use of internship programmes in both the private and the government sector.

Examples of Co-operation

- Numerous examples of international co-operation in the area of education and training exist.

- OLADE has offered numerous seminars on planning and energy balance methodologies.

- We need not go into details of the many exchange programmes among the world's universities and scientific institutions.

- In the International Energy Agency's stagiaire programme, we offer a limited number of short-term apprenticeships to young professionals, including some from developing countries.

R&D

- The IEA has an active programme for co-operation on research and development among its member countries to jointly develop specific research projects.

- The programmes administered by the IEA are not limited exclusively to IEA member countries. Indeed, developing countries are welcome to participate on a comparable basis with IEA member countries: that is, each participant is expected to contribute to some aspects of the project. The contributions have taken various forms: Data, scientific personnel, field sites, laboratory facilities, results of research in substantial progress; and in the case of a few large hardware projects, of course, financial resources. We have had discussions with a number of developing countries, and one is already participating in a project relating to one of its important primary energy resources.

The Agency's collaborative programme for the rational use of energy consists of projects in the following areas:

RESIDENTIAL AND COMMERCIAL

- Energy Systems and Design of Communities

Development of an integrated approach to community planning and energy systems design, to ensure that total energy balances are duly optimized. The results of this methodological work will be of interest to planners and architects of new communities, and for re-design of older communities.

- Research into Building Energy Load Calculation

This work has both theoretical and practical aspects. The theoretical is centred upon comparison of computer models for building energy load calculations and on improved understanding of the interplay of various parameters. The practical work ranges over actual field measurement on existing buildings and model verification, and analysis of air infiltration and quality. Results can be of direct use to energy-conscious architects.

- Utilization of Waste Heat Sources

Here the programme has two broad aspects:

- the development of large scale storage systems to accumulate relatively low-grade heat, either rejected from electricty generation or industrial processes or derived from solar collectors. Two practical demonstrations are underway: one in Switzerland employing an aquifer; one in Sweden on the design of a scheme operating from solar collectors and coupled with a district heating scheme.

- Evaluation and analysis of heat pumps either for individual domestic application, for district heating schemes or for use in industry. These studies have broad applicability in any situation where substantial quantities of low-grade heat are available for conversion. A comprehensive Information Centre on Heat Pumps has also recently been set up under IEA auspices.

- Total Energy Generation Concepts

This work has comprised technical studies of the more sophisticated applications of thermodynamic cycles to achieve high efficiency (55%) triple conversion process of primary heat into electricity, by cascading heat through three different turbine systems. The economics of such systems are still under examination, and may have a hard time competing in the present economic climate.

TRANSPORTATION

IEA technical collaboration in this area has so far been limited to:

- Combustion Research

  Fundamental investigation of the processes and phenomena occuring in the combustion chambers of automotive engines, furnaces and boilers and the development of predictive computer models. During the course of this work some fairly sophisticated diagnostic and measuring devices have been developed to enable theoretical models to be checked against actual experiments.

- High Temperature Materials

  Keynote of this work is the development of ceramic materials which will enable automotive engines to operate at high efficiencies. The experiments carried out may be regarded as taking one stage further the work described immediately above.

INDUSTRY

Efforts here have concentrated on some of those industrial processes which are the most energy intensive, notably:

- Cement Manufacture

  Studies and experiments on blended cements with higher slag content: determination of maximum permissible sulphate levels; and alkali-silica reactions arising from the addition of fly ash. Some complementary work on aggregate compatibility has also been carried out.

- Iron and Steel

  Study on the feasibility and potential energy savings of the Coal-Iron Gasification process, as well as the economic and environmental aspects involved. This is intended to lead to the eventual design and construction of a demonstration plant.

- Pulp and Paper

Work is focussed on three activities, notably increasing the thermal efficiency of the kraft recovery boiler; improving energy conservation in mechanical defibration, beating and water removal; and developing an energy accounting method for pulp and paper manufacture.

Potential for Co-operation

Much of the above described activities could be of interest to and application within rapidly developing industrial economies such as in Latin America. Some of them are addressed to fairly broad subjects, as in the residential and commercial sector. Others relate more specifically to commercial product design and manufacture, e.g. automotive engine development and energy savings in industrial processes. Again, some of this work has already been completed, some of it will be coming to a conclusion fairly soon.

Of course, the IEA is not the only international organisation involved in research and development. In particular, OLADE has co-ordinated a number of projects in this area. The UNDP also helps to sponsor a number of R&D activities.

IV. ROLE OF ENTERPRISES

Substantive Issues

- Historically, national and multinational enterprises have contributed much to energy development, particularly in the areas of technological advances; exploration and production; commercialization of new techniques; financing; and education.

Examples of Co-operation

- Some of the best examples are right here in Latin America, including the many arrangements between OLADE and industrial concerns interested in developing and applying together new technologies for local needs, as well as activities between OLADE/CEPAL and industries in Europe to develop local coal resources.

- There will certainly be a variety of points of view on this issue, and solutions will depend heavily on other national policies in each country. However, the resources of enterprises, both public and private, are enormous and should not be overlooked in considering possibilities for international co-operation.

V. <u>CO-OPERATION BETWEEN INSTITUTIONS</u>

- All the ideas above indicate substantive issues in which international co-operation is more important, and highlight a number of examples in these areas in which co-operation exists.

- The list is by no means all inclusive.

- Now I would like to turn and focus not so much on these substantive areas but on the active forms of co-operation between national, regional and international organisations.

- Most international and regional organisations have active information data exchange programmes. For example, information exchanges already exist between various UN agencies, the IEA/OECD, the EEC in Brussels, various UN Regional Commissions and OPEC.

- Another example is the very active co-operation between the various regional development banks and other regional organisations involved in the energy area. The most striking example here is the active and long-standing co-operation between the World Bank, the Inter American Development Bank and OLADE in funding and managing not only specific energy projects, but developing energy resources in Latin Anerica and also developing data bases, information systems and training programmes. Of course, one cannot forget the many specific project agreements between the Development Banks and individual countries.

- IEA co-operation with OLADE takes the form of:

1. data and information exchange;
2. staff exchanges;

3. co-operation on the developing country energy data project;
4. OLADE will observe closely the IEA country review process;
5. IEA consultation with OLADE on data collection system.

- IEA co-operation with CEPAL could develop along similar lines.

VI. NAIROBI CONFERENCE: AN EXAMPLE OF COMPREHENSIVE INTERNATIONAL CO-OPERATION

- One of the foremost examples of wide-scale international co-operation recently was the Nairobi Conference on New and Renewable Energy Sources. This was a specific example where national governments, research institutes, university groups, regional organisations, and international organisations participated not only in the actual Conference itself, but also in the detailed preparations of the Conference that spanned a period of well over a year before the Conference took place.

- This Conference, although concentrating on new and renewables, touched upon nearly every main substantive issue in the energy field; including data and information; planning and policy development; education and training; and the need to involve the enterprise sector.

- As a result of the Nairobi conference, a detailed Plan of Action to encourage the development of new and renewable sources was launched.

- The basic institutional structures to carry out the Plan of Action are in place, and attention can now be concentrated on concrete implementation steps, many of which will require a high degree of international co-operation.

CONCLUSIONS

In summary, as can be seen from this lengthy catalogue, international co-operation in energy is already widespread. But the catalogue also suggests great potential for further co-operation. This can occur between countries, in bilateral or specific multi-lateral arrangements. In fact, this is by far the largest area of existing, and probably future, co-operation.

It can, and does, occur also in international organisations having broader purposes than energy; such as the many bodies of the UN family. By definition, it also occurs within the international organisations specifically dedicated to energy; and it has special importance as between those organisations. And as the Nairobi Conference demonstrates, it can also take place on a world-wide scale.

- The important issue is to instill the determination and develop the willingness to foster co-operation on the part of all types of institutions.

- International co-operation is a slow and often difficult process that requires concrete actions. Some of these may be less than earthshaking. But taken together they will eventually lead to major progress.

  This week's Seminar is a clear, and I think, shining example. It covered a lot of ground on substantive issues, and it has shown where further co-operation is required and could develop.

- Thus, I will not try to leave you with a list or catalogue of broad new projects for co-operation. I shall only say, let discussion such as we have had this week continue; let us continue to work hard on fulfilling other types of existing co-operation; let us try out new ideas whenever we can. I am confident that in this way we shall identify new ideas and projects for discussion and further programmes of effective co-operation will emerge.

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